

STRATIGRAPHY AND PALEONTOLOGY OF THE
WINDSOR GROUP (UPPER MISSISSIPPIAN)
IN PARTS OF CAPE BRETON ISLAND,
NOVA SCOTIA.

By

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Chairman, Departmental Committee on Graduate Students

ABSTRACT

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By

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of Ph.D.

This thesis is concerned with the stratigraphy and
paleontology of the Upper Mississippian Windsor group, as
these strata are developed in parts of Cape Breton Island,
Nova Scotia.

In Nova Scotia the Mississippian period is represented
by two sequences of rocks. The lower consists of dominantly
medium to fine-grained clastics and constitutes the Horton
group. The upper part consists of two groups, the Windsor
below and the Canso above. The Windsor consists of thick
sequences of massive red siltstones and shales, with inter-
calated limestones, dolomites and evaporites, the total
thickness approximating 2500 feet. The Canso group consists
of dominantly fine-grained clastics. The Horton has an
unconformable relation with the pre-Mississippian rocks,
and in some localities is overlain unconformably by the
basal beds of the Windsor group. The Windsor sequence

grades with seeming conformity into the Canso group, which is in turn usually conformably overlain by Pennsylvanian beds.

Previous workers have subdivided the Windsor at the type locality into five faunal zones, and the present investigation reveals that these zonal boundaries exhibit a fair degree of coincidence in the Cape Breton area. In certain zones species are not equally well developed in Cape Breton Island and in the type locality, and it has been found that more accurate correlations can be made on the basis of the associations of certain common species than by noting the presence of any single species. The five faunal zones were divided into smaller units to meet the needs of mapping in local areas, but these smaller subdivisions could not be applied on a regional basis.

Representative faunas from the Windsor strata in Cape Breton Island are illustrated and described. The stratigraphy of the Windsor group and the composition, preservation and ecology of the fauna are discussed in detail. The present study confirms the generally accepted correlation of the Windsor fauna with the European Viséan, but fails to indicate how this fauna correlates with essentially contemporaneous faunas in other parts of North America.

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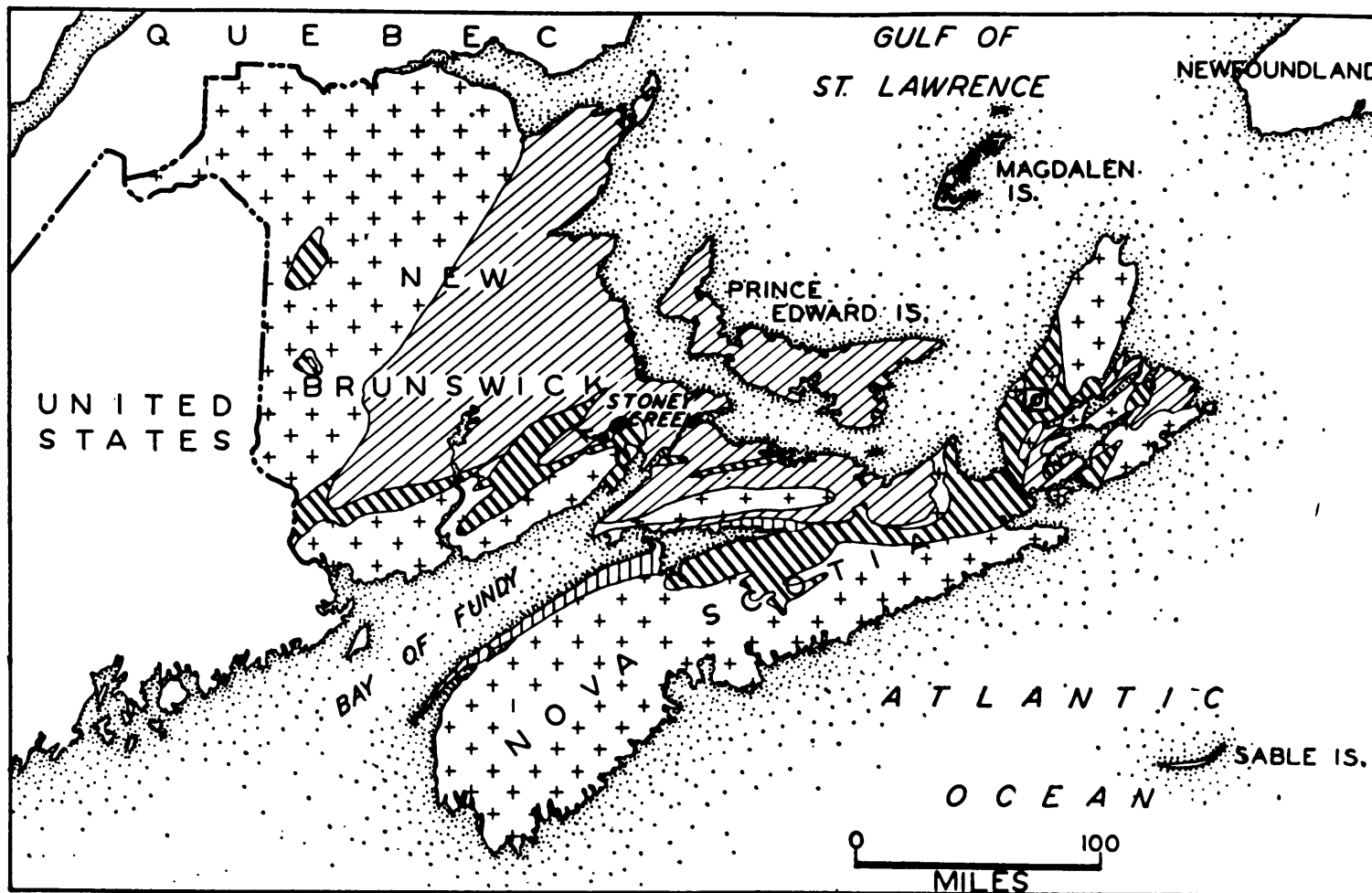
- Sheet 1. Key map showing location of collecting
areas, and of the area included in the
study.
- Sheet 2. Geologic map of the Mabou-Judique area,
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INTRODUCTION

GENERAL STATEMENT

The Mississippian System in North America may be roughly divided into four principal stratigraphic provinces. In the north-east, peculiarities of fauna suggest recognition of a separate province, variously referred to as the Eastern, Atlantic, Maritime, or Acadian province. In this general area a broad belt of Carboniferous rocks stretches, with interruptions, from central New Brunswick to eastern Cape Breton. It extends northeastward to New foundland. The region seems to offer the best possibility for correlative studies of the Mississippian on opposite sides of the Atlantic, and an important link between the Caney of Oklahoma and the Barnett of Texas, with their European equivalents.

The structural environment of these beds is a linear belt of subsidence along the continental border. It has been suggested that the water increased in depth toward the basin center to the northeast, and the presence of land masses or cratons to the west and northwest is inferred from the increasing coarseness of the sediments. The concept of a positive borderland to the south and southeast of the trough is in a state of flux. The region has been the center of repeated orogenic movements and stratigraphic studies in the Mississippian are greatly complicated by disturbance of the beds and facies change. A spectacular unconformity with distinct paleontological and lithologic breaks marks the



THE MARITIME PROVINCES

||||| TRIASSIC

\\ PENNSYLVANIAN

XXXX MISSISSIPPIAN

+ + + PRE-CARBONIFEROUS

Figure 1. Map showing general features of the Maritime Provinces.

contact between Lower and Upper Mississippian (Horton-Windsor groups) in most parts of the Maritime Provinces.

The Windsor group was named for Upper Mississippian strata exposed around the village of Windsor in the northeastern part of Hants County, approximately at the geographic center of Nova Scotia. This is the type area of Mississippian rocks in eastern Canada where the system was first studied by Sir William Dawson and C. F. Hartt. Lithologically the Windsor group consists of thick members of massive maroon siltstones and shales with thin beds of limestone and dolomite, and locally, thick deposits of gypsum. The lower part contains commonly a salt horizon and local conglomerates. The group overlies the Horton arkosic sandstones and underlies the Canso gray sandstones and shales.

Regional correlations of the Windsor are facilitated by the widespread distribution and continuity of the many thin diagnostic limestone beds. Well preserved marine fossils are numerous in certain horizons and provide a good basis for determination of the Visean age of the group. The general nature of the faunas is well known through the work of Bell (1929) at the type area. Paleoeologic studies are of special interest because the sedimentary rock cycles and their contained fossils represent contrasting environments associated with the periodic isolation of lagoonal basins in shallow seas. The lack of good continuous outcrops in the Lower

Windsor has caused a good deal of controversy and speculation concerning the exact sequence of the beds in that portion of the group.

Although the Windsor rocks in parts of Cape Breton have received considerable attention, careful zonal investigations have not been recorded. It is felt that investigation of faunas has lagged behind stratigraphic studies. The present work is an attempt to clarify the stratigraphy and paleontology of the Windsor beds in Cape Breton, and to work out regional relationships.

The field work for this report was done during the summers of 1949 through 1951. The Mabou-Judique area in the southern part of Inverness County was selected for detailed mapping and study mainly because of the spectacular sections along the Southwest Mabou River and on Hood Island. It is typical of the Windsor that no single locality in Cape Breton Island affords a complete and continuous section of all the beds known to occur in the A and B zones, therefore one must use many small outcrops to piece together a composite section. To determine the complete succession and establish faunal divisions in the greatly disturbed beds, it was necessary, in some instances, to assemble collections from widely scattered localities. Unfortunately some of the specimens are not precisely dated with respect to one another, nor as accurately located in the stratigraphic section as would be desired. The incomplete sequence found at the Mabou-Judique

area was used as a standard, and the stratigraphy of the Windsor group completed by adding the remaining members from their field relations in other areas. The area studied comprises those parts of Inverness, Victoria and Richmond counties shown on the map, sheet 1.

The island of Cape Breton is a little more than one hundred miles long and approximately eighty miles wide in its broadest extent. Except for a limited region bordering the southeastern shore of the island, Carboniferous rocks underlie the low areas bordering the island and surrounding Bras d'Or lake. The location and areal extent are shown on the map, sheet 1. Mainly pre-Carboniferous crystalline rocks occupy the cores of the major uplifts.

Much of the surface of the lowlands is covered with a mantle of glacial material. Although this cover is not so thick as it is in some parts of Nova Scotia, it is exceptionally even in its distribution. Only where the streams or the waves have succeeded in eroding away this cover, do the underlying rocks come to the surface. The Windsor beds are commonly found steeply tilted or overturned in complex thrusts or disharmonic folds, accompanied by sliding, crumpling and faulting. The waters of Bras d'Or lake cover a large belt of Carboniferous rocks, and swamps and alluvial deposits in many parts of the island cover about as much more.

Inasmuch as this study aims to demonstrate the stratigraphic relationship of the beds, the fossils have been

examined for their value in correlation. Thus the brachiopods are treated in more detail than the other groups. In the course of the work extensive fossil collections were made, mainly at favored localities where the succession of faunas could be worked out in more or less detail. The faunal list is accompanied by descriptions and illustrations of some of the forms. It is an annotated faunal list rather than a systematic discussion of the paleontology. Although some forms with uncertain specific affinities are cited, the author feels that their occurrence should be recorded and the specimens illustrated so that the identification can be readily verified.

The author with N. M. Sage, Jr. made a reconnaissance examination of the Windsor at the type locality. Three days of field work and subsequent laboratory examination of the resulting collections gave valuable information for regional correlations.

SUMMARY OF PREVIOUS INVESTIGATIONS

The major features of the Lower Carboniferous in the type area of the Maritime Provinces were worked out about one-hundred years ago by Lyell (1843) and Dawson (1847: 1855). Almost the earliest workers recognized that the Lower Carboniferous could be divided into two units, and Dawson's Upper, marine formation (later known as the Windsor series), and Lower, estuarine formation (later classified as the Horton

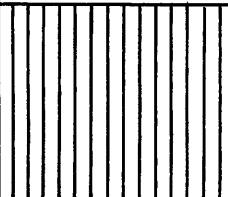
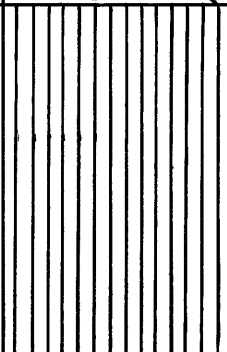
Europe		Maritimes General		Standard Divisions of Type Area	CAPE BRETON REGION				
					Hawkesbury	Sydney	Lake Ainslie	Mabou- Judique	
DINANTIAN	LOWER NAMURIAN	MISSISSIPPIAN	Upper	Canso gp. (max. th. 3000+ ft.)		Canso gp. 2000± ft.	Pt. Edward fm. 1250± ft.	Mabou fm. 3000± ft.	Canso gp. 3000± ft.
	VISEAN		Windsor gp. (2000+ ft.)	Subzones { E D C Subzones { B 350'+ { A	Windsor gp. 2000± ft.	Windsor gp. 4200- ft. Grantmire cgl.	Windsor gp. 2000± ft.	Zones { E D C Zones { B 1200'+ { A	
	TOURNAISIAN		Lower	Horton gp. (max. th. 8000+ ft.)	Cheverie fm. 800+ ft. Horton Bluff fm. 3400± ft.	Horton gp.		Horton gp. 6000± ft.	Horton gp. 5500± ft.

Figure 2. Correlations of Mississippian Formations of the Cape Breton Region.

series), have come down from his time with little change. As a result of Hartt's (1867:212) and Dawson's (1868:281) faunal studies, the Windsor series was subdivided into an Upper and a Lower member. Deposits containing similar fossil faunas were recognized at intervals in New Brunswick, the Magdalen Islands, Newfoundland and at scattered localities in Cape Breton Island. All these deposits can be referred to the Windsor, now considered to be a group, when used in its most extended sense. Bell's classic studies at the type locality led him to propose a three-fold division of the Carboniferous beds there; the Horton Bluff formation, the Cheverie formation, and the Windsor series (1929:30). His Cheverie formation has not been recognized outside the type area. After detailed treatment of the paleontological evidence Bell (1929:46) established two faunal zones in the Lower Windsor and three in the Upper.

Disagreement regarding the upper boundary of the Mississippian in the Maritime Provinces has been concerned principally with the proper placement of the Canso group. Summarizing the evidence, Bell says (1944:25), "So long as doubt remains about the precise upper limits of the Chester and lower limits of the Canso group in terms of European chronology, it would be hazardous to dogmatically place the Mississippian-Pennsylvania boundary in the Acadian province. From the present evidence, therefore, the Mississippian-Pennsylvanian boundary might be at the base of the Canso group,

at its top, or at some horizon within it". Bell now places the whole of the Canso group within the Mississippian System (personal communication) but his position, from the standpoint of correlation, has not yet been explained in print. The Geological Survey of Canada now refers both the Windsor and Canso groups to the Upper Mississippian (Descriptive Notes, Geological Survey Map 995, Mulgrave sheet, Nova Scotia, 1950).

In the Cape Breton region systematic geological mapping of the island was started by Robb and completed by Fletcher during the period from 1875 to 1890. Fletcher commented briefly concerning the distribution and nature of the rocks, but gave little detailed information and reported no fossils. Current knowledge of the Mississippian geology of the island has been derived largely from the studies of Bell, Weeks, Hyde, Norman and Hayes. Hyde examined the Windsor in the Sydney area (1912, p. 393) and listed species of Productus, Camarotoechia, Spirifer, Spiriferina, Composita, and Dielasma, but gave no descriptions or figures. He noted that several species are common to the lower and upper members of the Windsor, among them Productus cf. arseneau, Productus loevicostus, Pugnax dawsonianus, and Dielasma sacculus. He thought the fauna "differs considerably from that found in these limestones at Windsor, but several of the species are identical and there is no question as to the general equivalence of the beds".

The Mississippian strata around Lake Ainslie and Middle River were investigated by Trask and Mather in 1925 for the Gulf Oil Corporation. They subdivided the variegated beds into several formations and presented the following sequence for the Mabou region (Eastern Gulf Oil Company, 1928:274)

Pennsylvanian (?):

Mabou formation

Chiefly dark gray shales: 15 feet of gypsum in middle of formation	900'	900'
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MacFarlane Red Bed series

Upper MacFarlane-chiefly red sandstone and shales	1000'	
Middle Bridge formation - chiefly dark gray thin-bedded shales and intercalated thin limestone layers	250'	
Lower MacFarlane-chiefly red sandstone and shale	400'	1750'

Mississippian:

Hillsboro Limestone series

Gypsum	25'	
Red sandstone and shale	75'	
Oolitic limestone: black oolitic limestone and impure limestone	15'	
Red sandstone and shale	450'	
Canary limestone: rotten impure yellow limestone and limestone breccia	40'	
Red sandstone and shale	25'	
Gypsum	50'	
Red sandstone and shale	125'	

Ribbon shales: thin calcareous shales . . .	20'
Ribbon Limestone	30'
Red sandstone and shale	150' 1000'

Mississippian (?):

Dunbar Sandstone series

Ainslie Sandstones: medium and fine-grained sandstones; the rock in which the oil seeps and tar sands occur on Lake Ainslie 700'

Middle Dunbar groups

Dark gray shales (sandy)	75'
Mostly green sandstones	725'
Dark gray sandy shales	100'
Red, gray, and green sandstones . .	350'
Dark gray sandy shales	50' 1500'

Lower Dunbar Red Beds

Chiefly red crossbedded sandstones . . . 1200' 3400'

Kewstoke Conglomerate series

Chiefly coarse-grained arkosic sandstones and conglomerates 3000' 3000'
10000'

For the Lake Ainslie region, Trask and Mather substituted the name Judique series for the Hillsboro Limestone series (1927: 323). They noted that the following fossils were characteristic of the "yellow fossiliferous, cavernous limestone occurring in the middle of the Judique series at Middle River": Productus tenuicostiformis Beede, P. dawsoni Beede, Dielasma cf. D. sacculus (Martin), Composita dawsoni (Hall and Clarke), Aviculopecten sp., Parallelodon dawsoni Beede. They say "the fauna is thought to be more closely allied with

the Windsor fauna of the Magdalen Islands than with that of the Windsor District of Nova Scotia, and to be of Middle or Upper Mississippian age" (1927:324). The formation names used by Trask and Mather have not been adopted by Canadian geologists. Their combined Mabou-MacFarlane is equivalent to the Canso group; their Hillsboro or Judique represents the Windsor group; and their combined Dunbar-Kewstoke is referred to the Horton group.

Bell (1926:105c) examined the Mississippian strata around Lake Ainslie, where he recognized the Windsor A, B and C limestones, comparable with the divisions used on the mainland of Nova Scotia. Diaphragmus tenuicostiformis was reported from the Lower Windsor and a pelecypod, genus Schizodus, from the Upper.

Norman (1935) published a memoir on the geology of the Lake Ainslie area and he divided the Windsor into an Upper and a Lower member. The Upper, characterized by Martinia galataea, was thought to be equivalent to the C, D, and E zones at Windsor (1925:33). In the "Schizodus" dolomite beds, Norman listed Productus (Avonia) spinocardinata, Martinia galataea, Schizodus? and Euphemus cf. urei (1935:42). He cited additional Upper Windsor beds with Productus lyelli, Composita windsorensis, Composita strigata, Diaphragmus tenuicostiformis, Dielasma sp. and Bellerophon sp.

His list for the Lower Windsor includes the following:

<u>Spirobis</u> sp.	<u>Flemingia dispersa</u>
<u>Dielasma mesaplanum</u>	<u>Serpula annulatus</u>
cf. <u>Composita strigata</u>	<u>Productus lyelli</u>
<u>Pugnax</u> sp.	<u>Composita</u> sp.
<u>Aviculopecten</u> sp.	<u>Dielasma latum</u>
<u>Leptodesma acadica</u>	<u>Cranaena</u> sp.
<u>Parallelodon?</u>	<u>Fenestella?</u>
<u>Murchisonia</u> sp.	

Descriptions and illustrations of the fossils have not been included in any of the published descriptions of Windsor strata in Cape Breton.

Evidence of oil seepages from the Carboniferous rocks has been found in different parts of Cape Breton Island. Exploratory work and drilling of wells in the search for oil has been carried on intermittently since about 1870. Recent investigations in Inverness county include those made by the Eastern Gulf Oil Corporation in the 1920's. The Lion Oil Company conducted geophysical surveys and drilled two deep wells on the structure just north of Southwest Mabou Post Office during the period from 1943 to 1946. The results of these studies have not been published.

PURPOSE OF THE STUDY

The overall purpose of the present work was the study of two main problems as follows:

1. Mississippian stratigraphy in the vicinity of the Mabou-Judique area, Inverness county, Cape Breton Island.

The work undertaken consisted of detailed mapping of the area, a study of the various rock types present, and interpretation and understanding of the biological and sedimentary processes.

2. Study of the Windsor fauna in Cape Breton, to determine whether Bell's faunal zones are natural subdivisions on a regional basis and of practical value to the stratigrapher, or whether it might be necessary to erect parallel zones based on separate groups of organisms.

The type-area of the Windsor has, in the literature, remained hitherto a more or less isolated self-contained unit, the zones of which have not been traced with any degree of precision much beyond its boundaries. It seemed desirable to determine whether the Windsor faunas in general are limited to relatively small provinces, or whether they could be used in the satisfactory correlation of zones over considerable distances. It was not known (1) whether any of the species range more widely than indicated by Bell's studies at the type area, (2) whether the stratigraphic distribution of the fauna was a matter of age relationship and not of facies.

ACKNOWLEDGMENTS

In the preparation of this report extensive use has been made of the early government reports of Dr. W. A. Bell. The Government of the United States through the Veterans Training Program of the Veterans Administration provided most of the funds for this work. Parts of the field expenses were provided by the Nova Scotia Department of Mines and the Nova Scotia Research Foundation. The Department of Geology of the Massachusetts Institute of Technology granted a scholarship to support certain portions of the work and furnished facilities for laboratory studies.

Professor W. L. Whitehead encouraged the author to pursue the problem, and gave valuable advice on all phases of the work. He arranged for financial aid at certain crucial periods. Professor R. R. Shrock worked closely with the author and contributed generously to the solution of paleontologic problems. He permitted the writer to use his unpublished manuscript, "Principles of Invertebrate Paleontology" (Shrock and Twenhofel). The collections of Windsor fossils in the National Museum of Canada were made accessible to the writer, and Drs. W. A. Bell and A. E. Wilson showed every kindness. Grateful acknowledgments are due to the following persons for technical aid: Dr. G. A. Cooper of the United States National Museum for suggestions and for permission to examine the specimens in his charge; N. M. Sage,

jr. for many valuable hours during which the problems were discussed and suggestions offered; George Curran and N. M. Sage, Jr. for photographic work; Claude Hill and R. B. Leonard for their assistance in the field. Throughout the entire study the writer has had the generous cooperation of the officers and scientists of the Nova Scotia Department of Mines, the Nova Scotia Research Foundation, and the Geological Survey of Canada.

All the fossils figured herein and considerable additional material from the type locality are to be placed in the collections of the Nova Scotia Centre for Geological Sciences.

GENERAL GEOLOGICAL RELATIONS

TECTONIC SIGNIFICANCE

Cape Breton Island lies in a part of the deformed zone of the Appalachian belt which extends from Alabama through New England to Newfoundland. The general trend of the regional structure is toward the northeast. During Carboniferous time the sedimentational environment seems to have been distinctly different from that farther south, where the evidence for a coastal plain environment is strong. In Nova Scotia, Professor Whitehead (personal communication) has suggested an analogy with the California type of "basin and range" structure during Tertiary time. Carboniferous history in Nova Scotia is a complex pattern of islands and basins, with intermittent downwarping of relatively small basins and vigorous uplifts of land masses. Serious rupturing of the basement resulted in block faulting and folding, and the more plastic cover was compressed and crumpled into fantastic forms. As a result of displacement of the broken segments of the crust, the basement complex of pre-Carboniferous metamorphic rocks was in certain places greatly elevated, while adjacent areas were relatively depressed. Thus today the Carboniferous strata generally underlie the lowlands at elevations hundreds of feet lower than the pre-Carboniferous uplands, from which all of the Paleozoic sediments have been removed by erosion.

In Cape Breton Island the Mississippian sediments outcrop, with interruptions, around the pre-Carboniferous highlands in a series of embayments or irregular bands, dipping off the deeply dissected metamorphic areas. The section begins with the Horton clastic sediments, quite variable in lithology and thickness. They are unconformably overlain by the Windsor marine beds. The Windsor passes directly upward into the basal sands of the Canso, in which arenaceous material becomes increasingly important upward in the section.

THE AREAS STUDIED

The Mabou-Judique area in the southern part of Inverness county was selected for detailed mapping and study. Inasmuch as the main fossil zone (the B₁ limestone) is lacking at this locality, and continuous exposures of the lower beds are absent, it was necessary to make collections from outside areas. Good exposures of the main fossil zone were examined at the following localities:

- (1) Johnstown Quarry, on the south shore of Bras d'Or Lake, in the northeastern part of Richmond county.
- (2) Irish Cove, on the south shore of Bras d'Or Lake, at the boundary of Richmond and Cape Breton counties.
- (3) Near the village of Middle River in the southern part of Victoria county.
- (4) Cape Dauphin, on the eastern shore of Cape Breton Island near St. Ann Bay, Victoria county.

- (5) South shore of Aspy Bay, near Dingwall, in the northern part of Victoria county.
- (6) North shore of Lake Ainslie, in the central part of Inverness county.

At localities (4), (5) and (6) collections were made from both Upper and Lower Windsor beds. Corals from zone C were collected at Grand-Etang on the northwestern shore of Cape Breton Island, in the northern part of Inverness county. Inasmuch as some of the collecting localities are rather widely distributed geographically, the sampling was not ideal. The seven localities listed above were selected for study because they produced a number of fossiliferous samples. In the accompanying faunal lists not all the species listed from a single zone came from a single faunule.

MABOU-JUDIQUE AREA

STRUCTURE

The area lies along the northwest shore of Cape Breton Island. It is bordered on the east by St. Georges Bay, and on the north by the Lake Ainslie quadrangle (Norman, 1935). In the southeastern corner of the map-area, a belt of volcanic and intrusive rocks and of altered sediments forms an elongated upland, Craguish Hills, about 25 miles long, averaging about 800 feet above sea-level, and trending north 30° east. The sediments of this upland include large areas of George River rocks, mainly schistose quartzites and crystalline limestones, considered to be of Pre-Cambrian age.

The local structure of the area consists of a north-northeasterly trending synclinorium, limited on the southeast by the Caignish Hills. It represents the southwest extension of Norman's "Mull-Hay-Southwest Margaree syncline" (1935:24). Its axis roughly corresponds with that of the Caignish Hills upland. For three to four miles northwest of this crystalline highland, sediments of the Horton group are found in the headwaters of Mull River, Southwest Mabou River, and Judique Intervale Brook. Dips are regionally northwestward away from the metamorphic complex. In no place has an undoubted outcrop of the Horton group in this section shown reversal of dip. Strikes vary from north to northeast; dips are generally from 30 to 50 degrees. The width of the Horton outcrop indicates a thick section of these sediments. The character of the sediments, composed of arkose and conglomerate in the lower part, justifies the assumption of marked changes of thickness, especially near the base. Lack of parallelism between the Horton-crystalline contact and the strike of the higher beds in the group confirms such an inference.

Upon this monoclinal structure are superimposed various folds in which the complexly faulted anticlines are more conspicuous, with more abrupt dips than those of the intervening basins. In general the axes of these anticlines trend parallel to the regional strike, and the structures plunge toward the southwest. The area of Horton sediments is bordered on the

northwest by steeply dipping, overturned and cross-faulted Windsor beds. The outcrop of the Windsor group is narrow, less than a mile wide. Dips are erratic, and change of strike from north near Judique to northeast defines a broad warped plunging anticlinal fold on the regional structure, with its axis near the mouth of Judique Intervale Brook. This structure is a continuation of the southwesterly plunging anticline near Mull River to the northeast. At Middle Bridge this anticline, complexly faulted, may be determined in part by the folding and faulting of the E₁ dolomite.

Three and a half miles northwest of the "Middle Bridge anticline", a second long narrow anticline parallels the Middle Bridge structure. In 1944 two deep wells were drilled on this structure at a point just north of Southwest Mabou Post Office. In the first hole, the Windsor salt zone was encountered at 1395 feet, and the bit was still in the salt at 5580 feet. The second test, drilled about half a mile from the first, encountered salt at 4480 feet, and the base of the salt had not been reached when the hole was abandoned at 6870 feet (Ball et al, 1951;479). Professor Whitehead has studied the area in some detail, and as a result of these studies, together with geophysical data and drill core data from the two deep wells, he has interpreted these tectonic phenomena as piercement folds, or outbreak folds (personal communication). The soft plastic Windsor beds were

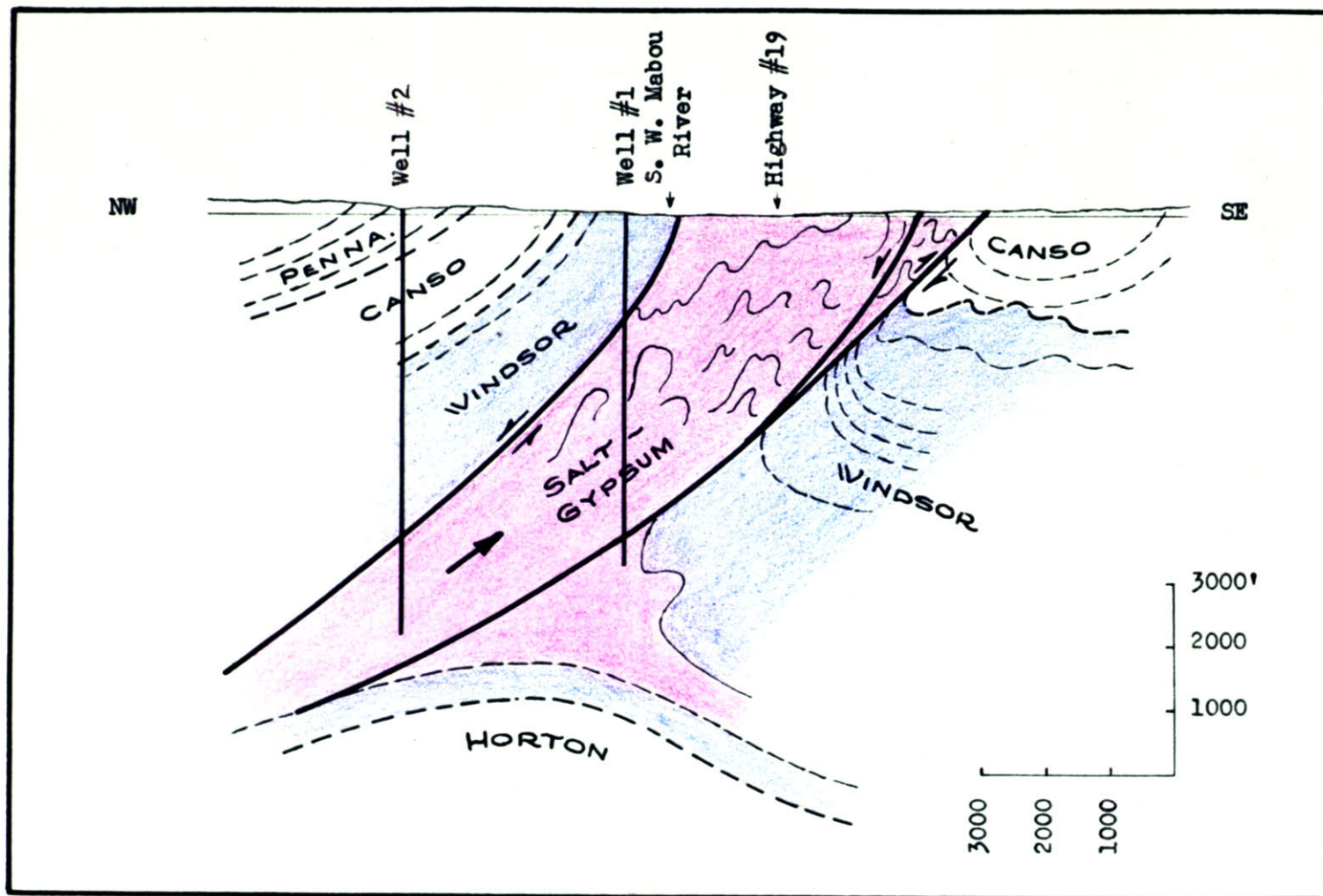


Figure 7. Diagrammatic geologic section of a piercement fold in the Mississippian beds. The two deep wells are located about one mile northwest of the Southwest Mabou Postoffice. After W.L. Whitehead and D.J. MacNeil (personal communication). A somewhat similar structure is present in the Middle Bridge anticline on the Southwest Mabou River.

caught between two strong competent series of beds, the heavy sandstones of the Horton below, and Canso-Riversdale above. In the basement, the Horton sands came up as a simple fold. Thrust faults and shear zones in the Windsor were channels for the intrusions of the thick evaporites of the B zone, which acted as lubricants for the over-riding block. The siltstones and limestones in higher levels of the Windsor were locally fractured and bent at acute angles during the deformation that culminated in the overthrusting, while the salt and gypsum-anhydrite yielded largely by flowage under pressure. At the apex of the fold the harder limestone members pierced the roof formed of the more competent Canso beds, and the whole Windsor mass squeezed up through the gap. At Middle Bridge the over-riding block is broken by cross faults, and beds of the E zone are sharply overturned, commonly striking at right angles to the axial plane of the major fold. The number and complexity of the cross faults decrease to the southwest of Middle Bridge, where the E₁ dolomite outcrops in the upper waters of Little Judique Brook. Still farther south, where the A₁ limestone outcrops in Judique Intervale Brook, the structure is undefined.

Northwest of the Windsor outcrops in the "Middle Bridge anticline", a corresponding fold is found in the Canso group. These Canso sediments extend for three and a half miles northwest of their faulted contact with the Windsor group.

Near the contact dips are steep; farther west in Little Judique Brook and north of Little Judique post office the beds flatten (average dip 35 degrees). The unusually wide outcrop of the Canso group in this area indicates complexity of structure. Few exposures are found in the central critical part of the area and data are insufficient to define the structure. The Canso group may be repeated by faulting. Farther west near Ragged Point the Canso and Windsor beds are in contact. Dips are reversed in both the Canso and the steeply dipping Windsor sediments.

Along the sea-coast west of the Windsor outcrops, coal-bearing beds of the Riversdale group are found with the normal westerly regional dip. They are in faulted contact at their eastern border with the Windsor group. The structure of this area between lower Little Judique Brook and the sea is interpreted to be that of a faulted anticline extending northeastward under the alluvium along the railroad west of Pt. Hood village. It is probably a continuation of the Southwest Mabou anticline.

STRATIGRAPHY

UNDERLYING HORTON GROUP

At almost every locality in Nova Scotia where basal Windsor rocks are exposed, they are underlain by the Lower Mississippian Horton group. The Horton-Windsor contact is always well defined and easily located, and in certain localities a marked angular unconformity separates the two groups (Norman, 1935:31). In the Boisdale Hills of eastern Cape Breton Island, Bell has identified a Devonian flora in rocks with a lithology similar to the Horton (Norman, 1935:24). Therefore the possibility exists that, in the present author's map area, the lowest members as mapped may be of pre-Horton age.

At the type locality in Windsor, the Horton group varies from 1,600 to 4,000 feet in thickness. In Cape Breton Island 6,000 feet of Horton rocks were measured in the Lake Ainslie map-area, and 3,600 feet at the Strait of Canso. In the Lake Ainslie area Norman made a lithological division into two parts; coarse gray arkosic sandstone and conglomerates below, and red and gray sandstones and shales above. Owing to lateral variations, as well as to lithologic similarities of the thick non-fossiliferous sections as a whole, well marked subdivisions of the group have only local value.

In the Mabou-Judique area the exact nature of the stratigraphic contact between the Horton and pre-Carboniferous rocks is unknown, as the strata have not been seen in actual contact. However, near the headwaters of the Southwest Mabou River the general attitude of the sediments and the absence of fault-line scarps suggest that the strata there rest in their normal position on the floor of marble and quartzite. There is an excellent exposure of the Horton group along the Southwest Mabou River. From the Horton-Windsor contact 1.5 miles downstream from Upper Bridge, a section is as follows:

Windsor A₁ limestone.

Horton group

- 250' About 85 percent interbedded gray and red shaly sandstones, and 15% gray to red shales.
- 500' About 75 percent medium-grained gray to light buff sandstones, and 25 percent gray to grayish-green shales. Sandstones frequently cross-bedded.
- 1400' About 55 percent gray to light gray fine-grained sandstones, and 40 percent gray sandy shales, with a thin bed of limestone conglomerate.
- 1200' About 50 percent red fine-grained sandstones and 50 percent red shales, frequently calcareous; thin bands of chocolate fine-grained sandstones and a few thin gray limestones.
- 400-2000' Gray to pinkish gray coarse-grained arkose interbedded with gray to grayish-purple conglomerate in beds up to 50 feet in thickness.

Crystalline complex.

In the lower part of the section continuous exposures were not available, and the measurements serve only to indicate the general order of thickness. The section along the Southwest Mabou River certainly has a minimum thickness of 3700 feet and is probably about 5500 feet thick.

The Horton-Windsor contact is well exposed in many parts of the area and shows the same lithologic sequence in every locality. The upper 18 inches to 2 feet of the Horton group is a gray fine-grained sandstone, usually cross-bedded. The base of the Windsor is well defined by a laminated (ribbon) limestone, 25 to 50 feet thick. The best exposure of this contact is found outside the map-area, along the Mabou River at a point one mile south of the Hillsborough post office.

OVERLYING CANSO GROUP

The fossil evidence of the age of the Canso group is inadequate. The few fossils found are mollusks and crustaceans and not significant for dating. The more abundant land plants are generally too much macerated to permit exact identification. Bell (1944:10) states that the most signi-

ficant features which differentiate the Canso from succeeding groups are (1) "the absence or rarity of conglomerate in Nova Scotia; (2) the widespread distribution, horizontally and vertically (except in the Cumberland basin facies) of laminated, rippled, and mud-cracked beds carrying a fluvio-lacustrine fauna". He adds: "thus the Canso deposits indicate generally that the Fundy geosyncline in Canso time was an area of low relief undergoing progressive subsidence and aggradation".

In the Sydney area the Canso group is represented by two equivalent clastic formations, the Point Edward which is dominantly red (Map 361A, Sydney Sheet, 1938) and the Cape Dauphin which is largely gray (Map 359A, Bras d'Or Sheet, 1938). In the Lake Ainslie area Norman's Mabou formation is about equivalent to the Canso group. It is clastic except for some thin calcareous beds near the base. The name "Canso" was proposed by Bell for a series of red and gray shales and fine-grained sandstones overlying the Windsor group at the Strait of Canso (Ferguson, 1946:11). Inasmuch as the Windsor-Canso and Canso-Riversdale contacts at the type section are not exposed, it is difficult to solve problems concerning the contacts at the type area. No evidence of disconformity was found between rocks of Windsor age and the Canso beds at the type section or at several other sections studied in the area. Although Windsor species do not occur in the Canso the merging

of the thin algal beds intercalated with gray shales into the calcareous gray shales of the lower Canso suggest a gradational contact. The Canso has, however, been reported to be unconformable on the Windsor, in a section taken by N. M. Sage, Jr. in the Antigonish area (personal communication).

At most localities of outcrop in the Mabou-Judique area, the buff sandstones of the Lower Pennsylvania Riversdale group rest on the uppermost beds of the Canso. The actual contact at most localities is visible only for short distances, if it can be seen at all. It has not been possible to establish zones in the basal part of the Riversdale or in the upper part of the Canso by which a short break in deposition might be detected. Although Canso plant beds are not abundant, the break in floral species at the Canso-Riversdale contact is quite clear-cut (Bell, 1944, fig. 10). In the map-area the contact with the overlying Riversdale beds is placed, arbitrarily, at the first appearance of coaly material, and the buff sandstones above it bear a closer lithological resemblance to the Riversdale sandstones than to Canso gray sandstones below.

At Ragged Point, 3.5 miles south of Port Hood village, Norman placed the Windsor-Canso contact at the top of an 8 foot bed of black gypsum (1935:39). At this same locality, the present author found a significant contact 285 feet higher in the section, at the top of a four inch algal bed. Leaia leidyi var. salteriana Jones makes its first appearance in the

blue shales immediately above this contact. The beds below this contact might be termed lower Canso in this locality. A similar contact is seen in the railroad cut three quarters of a mile north of the Southwest Mabou Post Office. Here again the upper limit of the lower Canso beds is a tabular botryoidal stromatolite, in thin layers, from four inches to a foot in thickness. The base includes about two feet of thin-bedded, greenish-gray, fine-grained sandstone which is followed by gray argillaceous shales. Another excellent place to see this contact is in the Southwest Mabou River channel, about one mile east of Glencoe railroad station. Here the upper 20 feet of the lower Canso includes three thin algal biostromes. The lowermost upper Canso beds consist of maroon calcareous shales.

Norman (1935:44) surveyed a 2900' section of synclinal Canso beds on the Southwest Mabou River north of Middle Bridge. The strata exposed here are about 60 percent shale, commonly argillaceous with intercalated beds of fine-grained sandstone, and about 40 percent red shale with intercalated sandstone beds. Some of the red silty sandstone beds contain abundant blue-gray calcareous concretions. An interesting feature is the presence of a 15 foot gypsum member, lying about 500 feet stratigraphically above the base of the group. This same gypsum bed is exposed in Canso beds along little Judique Brook, about half a mile northwest of the intersection of Beaton and Dunsmore Road. Throughout the

sequence the Canso is characterized by (1) remarkably even and persistent relatively thin bedding, (2) repeated alternations of beds of fine-grained sandstones and siltstones or shales, (3) extensive cross-bedding and ripple marks. Mud cracks, small flow-casts, and halite pseudomorphs are occasionally seen. Plant remains in the form of flecks of twigs and stems are locally abundant but usually fragmental. Plant fossils collected by the writer were identified by Professor L. R. Wilson as Lepidodendron preaelanceolatum, Trigonocarpus praetextus, and Calamites sp. At many horizons in the Canso the gray shales sporadically carry in abundance the valves of two species of pelecypods and a bivalve crustacean. The following forms were collected: Leaia leidyi var. salteriana Jones, Anthracomya angulata Dawson, and Modiolopsis sp.

WINDSOR GROUP

Bell states that the total thickness of the Windsor at the type locality in Hants county approximates 1500 feet, and that the top of the Upper Windsor section is lacking (1927:91). Here, as elsewhere in the Maritime region, the deformation is extreme and the limit of error is probably high. According to Bell, "gypsum may make up almost 20 percent of the total volume, red shale 55 percent and calcareous beds 25 percent" (1929:45). Paleontologically the Windsor group of

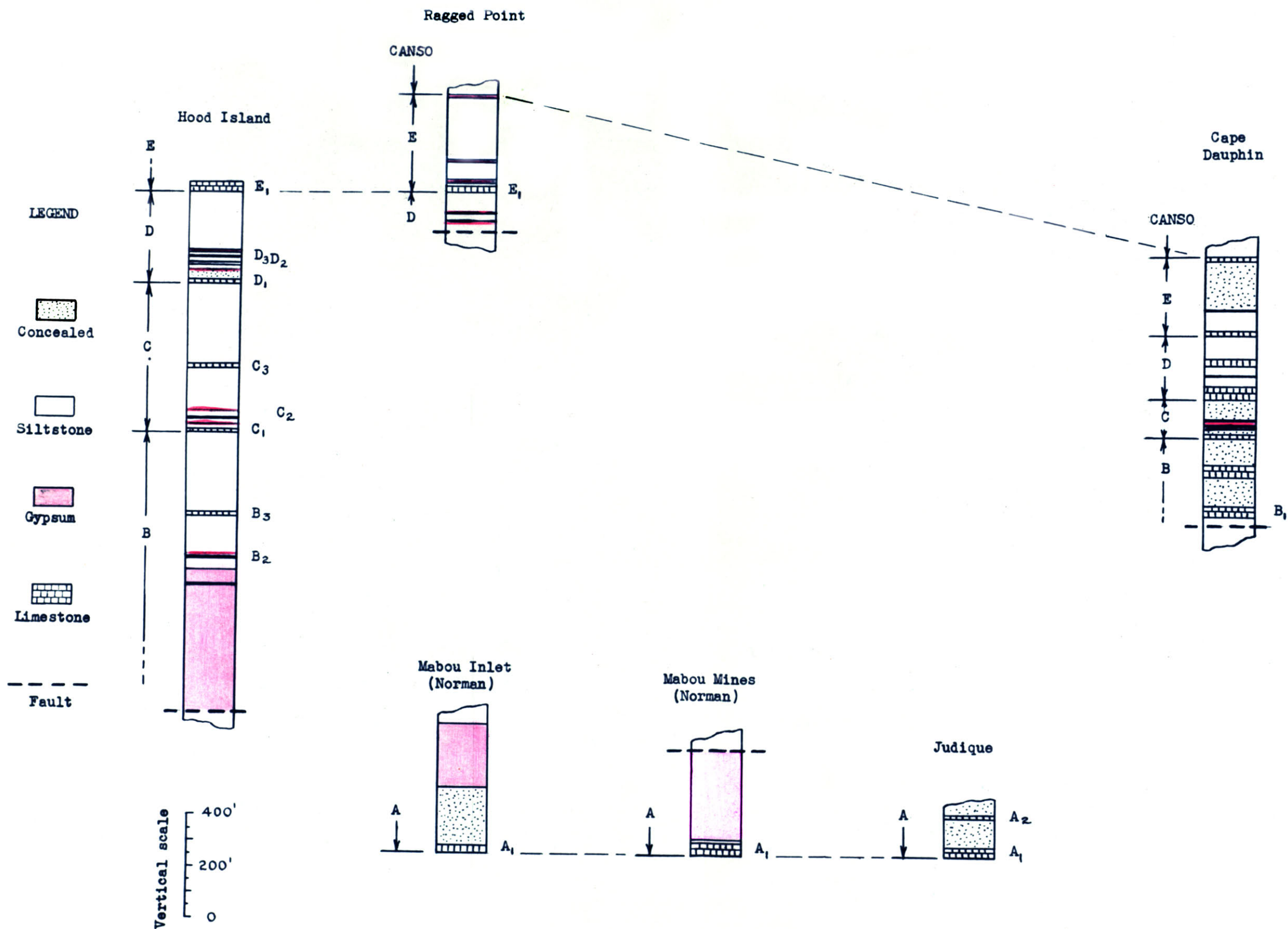


Figure 3. Geologic Sections of the Windsor Group.

the type Windsor area is broadly divided into two members:

Upper Windsor (= Upper Visean).

Characterized by presence of Martinia galataea and by certain productids and clisiophyllids and other columella-bearing corals.

Lower Windsor (= Middle Visean).

Contains many pelecypods and gastropods, indicators of facies rather than time. Characterized by presence of Composita dawsoni, Cranaena tumida, and certain bryozoans.

Further subdivisions of the group are as follows:

Upper Windsor.

Subzone E. Caninia dawsoni and Chonetes politus.

Subzone D. Productus semicubicalus.

Subzone C. Dibunophyllum lambii and Nodosinella priscilla.

Lower Windsor.

Subzone B. Diodoceras avonensis.

Subzone A. Basal limestone.

Bell comments on the peculiarities of the C zone (1927:91) with its "thin sandy dolomites, spongiostromid algal bands, and horizons with a very restricted faunal assemblage of minute shells comprising a few species of minute gastropods, pelecypods, ostracods, and foraminifera. The beds of this subzone therefore pre-eminently testify to a time of extreme shallowing of the sea".

In the Sydney area, Cape Breton Island, the Windsor varies laterally, resulting largely from the local presence of fanglomerates. Zone B of the lower Windsor overlies pre-Carboniferous rocks, with wedges into the Windsor Grantmire Conglomerate. Zone C varies from coarse red clastics to a succession dominated by limestone, anhydrite, and gypsum. Higher beds contain limestones and dolomites that are more widespread. In eastern Cape Breton Island, Bell states (1944:11): "fanglomerates of Upper Windsor age are present on Mira Bay, on the upper part of Sydney River, on the borders of Coxheath upland, and probably again as the St. Ann formation on St. Ann bay".

The writer's observations in the Mabou-Judique area indicate a thickness of the Windsor of the order of magnitude of 2,200 to 2,700'. This may be increased or decreased in the future when the exact sequence of the beds in the lower portion of the group has been determined. About 70 percent of the Windsor sediments consists of red beds with no traces of organic life. Gypsum and anhydrite average about 17 percent, salt 6 percent, limestone and dolomite about 7%. The group contains a faunal assemblage similar to, though numbering fewer species than, that of the Windsor at Windsor.

The uppermost Windsor beds are well exposed in the Mabou-Judique area at Ragged Point, 3.5 miles south of Pt. Hood village. A section was measured along the coast line in a northwesterly direction as shown on the following page:

Canso group (Upper beds). Specimens of Leaia leidyi var. salteriana collected in the lower 15 feet.

Canso group (Lower beds).

0.5' Tabular stromatolite consisting of thin, symmetrically curved laminae; 6 to 10" center to center of each hemispheroidal mass.

+115' Gray calcareous shales consisting of thin alternating silty and argillaceous layers, with a little thin-bedded maroon siltstone and shale.

0.5' Tabular stromatolite, similar to the bed listed above.

3' Shaly gray limestone, ribbon-banded, locally maroon.

84' Gray calcareous shale. There are a few 3 to 4" lenses of gray crystalline limestone present but they are quite subordinate to the shale.

6' Maroon shale.

0.5' Tabular stromatolite, similar to the two algal structures listed previously.

18' Calcareous gray shale with thin maroon lenses.

13' Maroon siltstone.

2.5' Gray arenaceous calcareous shale.

36' Maroon and blue-gray siltstone.

Upper Windsor group (Zone E).

- 8' Coal-black gypsum blotched with light gray gypsum.
- + 225' Massive maroon siltstone with occasional lenses of blue-gray shaly siltstone.
- 2.5' Black gypsum with scattered satin spar streaks penetrating the overlying siltstone beds.
- +69' Massive maroon and blue-gray siltstone with local gypsum veinlets.
- +15' Snow-white gypsum with scattered dark gray clay streaks; one inch selenite rosettes at the top.
- 12' Covered.
- 26' Gray dolomitic limestone weathered to a dirty rust color (E₁ dolomite). Schizodus cf. S. denysi found here.

Upper Windsor group (Zone D).

- 86' Massive maroon and gray-blue siltstone.
- 3' Pink to gray gypsum.
- 15' Alternating maroon and light blue siltstone with scattered gypsum veins.
- 9' Covered.
- 6' Gypsum, weathered to a dirty salmon color with streaks of dark gray gypsum.
- 32' Maroon siltstone, partly covered.

Fault

Pennsylvanian Riversdale group: gouge breccia.

The striking exposure along the north shore of Hood Island furnished the most complete continuous exposure of Windsor strata in the region. At the base of the section, vertical Windsor beds are in faulted contact with the Upper Pennsylvanian Inverness formation, so that all of the A zone and part of the B zone are cut out. At the upper end of the section all of zone E above the E₁ dolomite is concealed in the sea. The extreme deformation of the thick gypsum member at the base of the section makes the measurements of little value. The thickness of that member may be of the order of 350 feet. Below is a section measured from the tip of Point Vertical in an easterly direction.

Upper Windsor group (Zone E)

Covered by the sea.

45' E₁ dolomitic limestone. The lower 6' of this interval consists of hard massive gray oolitic limestone, slightly varved and locally cross-bedded. The next 6' has a similar lithology in which there is a prolific development of Schizodus cf. S. Denysi, with all valves convex upwards. The succeeding 5.5' is gray dolomitic mud-rock. It yielded a poorly preserved species of a tabulate coral. The

top 2 inch layer is peppered with unidentified brachiopods, mainly spiriferids. This grades into an upper 28' barren zone of hard massive, cream-colored dolomitic limestone. Geodes with crystalline calcite fillings are found here.

1' Calcareous platy gray shale.

Upper Windsor group (Zone D).

89' Calcareous, thin-bedded, red sandy siltstone; locally shaley, cross-bedded and ripple-marked.

3' Hard maroon silty sandstone, blotched with gray-blue coloring; cross-bedded, flow casts at base.

183' Predominantly crumbly, massive maroon siltstone; with local thin bands of hard, fine-grained maroon sandstone with some light blue mottling.

6' Light gray shale.

28' Dirty white gypsum with gray streaks.

3.5' D₃ limestone. Dolomitic lime mud-rock, weathering dark-gray to light-gray, poorly bedded. There are faint traces of algal structure in the middle part.

2' Gray shale.

12' White gypsum with one-quarter inch selenite rosettes. There are a few gray shale stripes in the upper part of the gypsum.

2.5' D₂ limestone. The top 16" is a massive silty limestone weathered to a rust-buff color; slightly

brecciated. The bottom part is a gray crystalline limestone.

- 2.5' Light gray shale.
- 24' Massive maroon siltstone, slightly calcareous, with occasional gypsum veins. The upper part contains a few thin lenses of gray shale.
- 10' White gypsum with small selenite rosettes.
- 21.5' Covered by bank slide.
- 18.5' D₁ limestone. The lower 1.5 feet of this interval is yellow lime mud-rock. The next 3.5 feet is a stromatolite made up of small digitate columns in irregular masses, giving the rock a mottle appearance in dark-gray and buff colors. Overlying this layer is a 9 foot bed of gray, buff-weathering, coarsely oolitic limestone, partly dolomitized. It is soft, porous, and friable. Three feet from the base, specimens of Diodoceras avonensis were collected. The upper 6' contains Martinia galataea (abundant), and Martinia thetis (common). All shells are disconnected, water-worn, and lie convex upwards. At the top is a single layer of unusually large ripple-marks. The upper 4.5' is a buff-colored, marly limestone.
- 0.5' Blue clay, slightly calcareous.

Upper Windsor group (zone C).

- 9' Mottled maroon and blue siltstone, massive.
- 24' Mottled maroon and blue siltstone with white satin spar veins (1/16 to 1.5") closely spaced and generally parallel to bedding.
- 178' Massive maroon siltstone with occasional stringers of gypsum.
- +3' Gypsum, mottled gray and white; slumped.
- 16' C₃ limestone.

The upper 45": massive buff-gray limestone, weathers cavernous. The next 5": dense, gray algal structures like large baker's buns, averaging 4" in height and 7 to 10" in diameter, resting on gray, layered oolitic limestone. The next 18": drab, oolitic limestone carrying abundant Martinia galataea. The next 36": Massive drab-colored limestone, partly oolitic. The next 30": Stromatolite made up of digitate algal structures. The next 30": Algal "reef", composed of unusually large massive algal columns of dense, gray limestone. The following species are present in the brown lime-mud matrix between and on top of the algal columns; dwarfed Beecheria davidsoni, Stegocoelia abrupta, Flemingia (Anematina) dispersa, Naticopsis howi, Nodosinella priscilla, and other unidentified foraminifera, ostracods, and possibly

bivalved crustaceans. The basal 30": massive drab-gray limestone, carrying Linoproductus lyelli var. a. in the upper 3".

- 1.5' Calcareous bluish-gray shale.
- 12' Crumbly, calcareous siltstone, maroon and bluish gray alternating.
- 119' Massive red to maroon siltstone with satin spar veins (2" maximum) running, in general, perpendicular to the bedding. In part mottled with blue.
- +4' Mottle gray and white gypsum; contacts obscure.
- 7' Maroon siltstone.
- +3' C₂ limestone. Slumped?
 The upper 4" is a yellow-weathering earthy limestone. The remainder of the bed is a rather massive-bedded, drab to buff-colored limestone. On the north side of Point Vertical headland it contains nondescript algal structures, roughly column-shaped but contorted. The exposure on the south side of the headland contains large algal masses in the form of domal growths about 6' in diameter. The huge blisters show up only on weathered surfaces where the laminae tend to peel off, leaving a depression like an inverted bushel basket.
- 15' Massive maroon siltstone.

+17' White gypsum containing scattered gray selenite crystals.
This bed may be slumped.

12' Maroon siltstone.

12' C₁ limestone. The upper 19' is a yellow, marly limestone. The lower 2' is a hard, fine-grained limestone, mottled, of dark bluish-gray color when fresh and has a knotty appearance. It contains botryoidal algal structures averaging 1.5" in diameter, with irregular pockets of coarse oolites. Martinia galataea are abundant in spots. There are a few unidentified brachiopods, comminuted shell matter, and crinoid stems.

Lower Windsor group (Zone B).

318' Massive maroon siltstone with occasional blue streaks. Contains pink and white satin spar veins generally perpendicular to the bedding.

16.5' B₃ limestone.
The upper 12": buff-colored, slightly oolitic, soft limestone. The next 18": drab-gray, coarsely oolitic limestone. The next 18": gray crystalline limestone with small digitate algal structures containing hard dark-gray cores. The next 12.5': thick-bedded coarsely oolitic limestone, the oolites dark gray in a soft brownish-buff matrix. The rock is massive and breaks chunky. In thin-section shell fragments and sponge

spicules form nuclei for some of the oolites.

Matrix contains abundant shell fragments and unidentified foraminifera.

- 1' Calcareous gray shale.
- 155' Massive maroon siltstone, locally calcareous, with some blue mottling. There are a few gypsum veins in the lower part.
- +8' White gypsum with selenite rosettes up to 1/2" diameter; some pink mottling. Contacts obscure.
- 13' B₂ limestone. The top 1' is buff-colored oolitic limestone. The lower 12' is a drab-gray coarsely oolitic limestone. In the field this member cannot be distinguished from the B₃ limestone. In thin-section the oolites are spherical or oval, averaging 1/2 mm. in diameter, the majority being dark gray calcite with concentric structure and sharp margins. The soft matrix contains shell-chips, spines, and foraminifera.
- 34' Massive maroon siltstone with some gypsum veins. In part mottled with light blue.
- +350' White to dirty white gypsum. From its upper contact to the fault zone at the base, this thick gypsum bed outcrops over a stratigraphic distance of about 560 feet. The lower part is highly contorted and it is not certain whether the beds are repeated by faulting.

The thickness indicated is merely a rough estimate. The upper 15' contains numerous thin clay seams. The next 135' contains irregular masses of pink and white gypsum breccia with clay streaks. Near the middle of the mass there are small selenite rosettes which increase in size toward the fault zone. About 70' below the upper contact there is a 30" layer of dark-gray to buff marl.

Fault

Upper Pennsylvanian Inverness formation.

At Cape Dauphin on the eastern shore of Cape Breton Island, Upper and Lower Windsor beds are exposed. At the base of the section the Windsor rocks are in faulted contact with Pre-Cambrian (?) granite. In the Descriptive Notes of Geological Survey Map 359A (Bras d'Or Sheet) 1938, Bell and Goranson say: "550 feet or more of Lower and Upper Windsor limestone and calcareous shale with red and green shale interbeds are exposed. The lowest limestone member is a massive fossiliferous member, about 50 feet thick, of Lower Windsor age, and it is capped by 40 feet of arenaceous limestone that carries pebbles of granitic rocks. Overlying this latter bed are thinly bedded or flaggy limestones, in part brecciated, belonging seemingly to basal part of the Upper Windsor, and gypsum blocks suggest a concealed gypsum member. The top beds of the Upper Windsor include bands of oolite and thinly bedded limestone".

Although many of the beds are poorly exposed, the sequence here seems to represent a continuous and conformable succession. It includes the main faunal zone and the critical interval above it, thus establishing the stratigraphic position of the B₁ limestone. When compared with the Hood Island section, it is apparent that many of the limestone lenses have changed their character, and do not hold a constant position in the column. They vary considerably in thickness, and some limestones present in one section are absent in the other. The distance between the two localities is considerable (about 60 miles) and limestone lenses so variable in their lateral distribution do not seem to offer a firm foundation upon which to establish zones. Nevertheless, generalized zonal divisions are tentatively proposed in the section below. The section is measured from the northeastern tip of Cape Dauphin in a westerly direction.

Canso group.

Calcareous, arenaceous, gray-blue, ribbon-thin shales interbedded with lenses of hard gray limy mud-rock in beds 2 to 6 inches. In the lower part, Leaia leidy var. salteriana were collected.

Upper Windsor group (Zone E)

12' Hard, whitish-gray lime mud-rock. Upper 30" is massive; the lower part in beds 2 to 12". Contains sparse vugs lined with calcite crystals.

180' Covered. Some small discontinuous exposures of maroon siltstone.

+4' Poorly exposed, dense gray crystalline limestone in beds 2 to 6".

85' Maroon siltstone with blue mottling.

18' Gray crystalline limestone, thin to thick-bedded, in beds up to 20", with irregular thin oolitic bands. About 6' from the bottom there is an 18" horizon containing digitate algal structures. The following species were collected: Conularia planicostata, Batostomella exilis, Schellwienella sp., Productus productus var. tenuicostiformis, Linoproductus lyelli var. a., Ambocoelia? acadica, Martinia galataea, and Beecheria davidsoni.

Upper Windsor group (Zone D).

80' Poorly exposed maroon siltstone in part interbedded with light blue.

+25' Platy, thin-bedded, gray crystalline limestone in beds to 3". Martinia galataea collected.

45' Poorly exposed maroon siltstone.

+6' Poorly exposed shaly gray limestone.

40' Maroon siltstone with blue mottling.

+50' Gray arenaceous limestone in beds to 12". Some parts are fractured. A few Martinia galataea collected here.

Upper Windsor group (Zone C?)

- 80' Concealed.
- +6' Poorly exposed gray, fine-grained limestone; weathered surface blocky and iron-stained.
- 44' Concealed. Large gypsum blocks indicate concealed gypsum member within this interval.
- +10' Poorly exposed arenaceous gray limestone, in part brecciated.

Lower Windsor group (Zone B?)

- 95' Concealed.
- +40' Poorly exposed arenaceous limestone, in part blocky and cavernous. The upper part contains lenses of limestone breccia with some igneous pebbles. Contacts concealed.
- 105' Concealed.
- +50' B₁ limestone. Massive, dirty gray, coquina-like limestone. Weathers buff and decomposes readily so that the fossils can be collected loose on the surface. Upper contact concealed. The abundance of pelecypods, gastropods and bryozoans is largely confined to the lower two-thirds of this unit. The basal third is particularly rich in conularids. The upper third contains myriads of brachiopods. Irregular shadowy worm markings can be seen locally. Following species present: Nodosinella priscilla, Conularis planicostata,

Fenestrellina lyelli, Batostomella exilis, Productus productus var. tenuicostiformis, Linoproductus lyelli, Linoproductus lyelli var. a., Pugnax dawsonianus, Composita dawsoni, Beecheria davidsoni, Beecheria latum, Beecheria milviformis, Cranaena tumida, Romingerina anna, Aviculopecten lyelli, Lithophaga poolii, Stegocoelia compactoidea, and Naticopsis howi.

+30' Poorly exposed. Small patches of maroon siltstone with blue mottling.

Fault.

Pre-Cambrian (?) pink granite capped with flat-lying Windsor conglomerate.

Upper Windsor beds outcrop along Middle River about 300 feet north of the highway bridge over Middle River, near Middle River Settlement. The beds in this section are steeply dipping, overturned, fractured and faulted. The complexity of structure caused doubt as to the thickness and repetition of the section by faulting, therefore a section was not measured. Fossils collected from a thin-bedded gray crystalline limestone about 10 feet thick are believed to be from Zone C. Linoproductus semicubicalus, Spirifer? sp., Martinia galataea, and an unidentified bryozoan are present.

Collections were made from the B₁ limestone at six separate localities in Cape Breton: at Lake Ainslie, Johnstown

Quarry, Irish Cove, Cape Dauphin, Middle River, and Dingwall. Unfortunately only at Cape Dauphin were the beds well enough exposed to determine the exact stratigraphic position of that member. With the exception of the exposure at Lake Ainslie, the lithology of the specimens and the general appearance of the rock are quite similar in all the localities where B₁ fauna was collected. Furthermore the faunas obtained at these localities are probably more alike than the list imply, and there is no reason to doubt that we are dealing with but a single faunal invasion.

At Johnstown Quarry, about 40 feet of the B₁ limestone may be seen, and neither the top nor the bottom are exposed. However, about a quarter of a mile east of the quarry, in a small road-cut on the Sydney road, the contact of the B₁ limestone with pink granite is seen. Across the road from Johnstown Quarry on the shore of Bras d'Or Lake, is a coquina-like bed about 10 feet thick composed entirely of crinoid stems. Although bedding planes are not clearly defined, this crinoid coquina appears to lie stratigraphically above the B₁ limestone. At the Quarry the B₁ limestone is massive, drab-gray, and coquina-like, weathering into a rotted-looking rock. The matrix in which the fossils are imbedded is an argillaceous lime-mud, which in weathered outcrop breaks down so that the fossils can be picked off the talus intact. The following species are present here: Conularia planicostata, Serpula annulata, Fenestrellina lyelli, Streblotrypa biformata,

Batostomella exilis, Productus productus var. tenuicostiformis,
Linoproductus lyelli, L. lyelli var. a., Avonia? sp., Pugnax
dawsonianus, P. magdalena, Shumardella sp., Composita dawsoni,
C. windsorensis, C. obligata, Spiriferina verneuili, Puncto-
spirifer sp., Beecheria davidsoni, B. latum, B. milviformis,
Cranaena tumida, Romingeria anna, Sanguinolites parvus,
S. striatogranulatus, Edmondia rudis, Grammatodon (Parallelodon)
hardingi, G. (P.) dawsoni, Aviculopecten lyelli, A. lyelliformis,
A. subquadratus, Naticopsis howi, Diodoceras avonensis, and
Stroboceras hartti?

On the north shore of Lake Ainslie an isolated outcrop of the B₁ limestone is seen. Along the shore about 1500' to the west there is a poor exposure of the A₂ limestone. It is impossible to determine the attitude of the beds at either locality and the interval between them is concealed. It is therefore impossible to determine the stratigraphic relationship between the two members. The B₁ limestone is hard and does not yield good specimens. It is light-gray in unweathered condition, but is readily altered to grayish-buff by exposure. The following species were collected here:

Conularia planicostata, Fenestrellina lyelli, Septopora primitiva,
Batostomella exilis, Productus productus var. tenuicostiformis,
Composita dawsoni, C. windsorensis. Beecheria davidsoni,
B. latum, Romingerina anna, Sanguinolites parvus, Aviculopecten
lyelli, Stegocoelia compactoidea, and Naticopsis howi. The

fauna of this section is undoubtedly more varied than is indicated by the list. There is in the collection taken from this locality a number of fragmentary specimens that are too poorly preserved for identification.

About 6000 feet south of the church at Middle River Settlement, in a road-cut on the road to Baddeck there is an isolated outcrop of the B_1 limestone. It is typical of the B_1 limestone that this outcrop is excellent for purposes of collection but is not the best place to see the lithologic sequence, for the strata are partially decomposed and the beds above and below are covered. The fossils collected at this locality are listed elsewhere in the report.

In Cape Breton the exact sequence of the Lower Windsor beds between the thick gypsum member and the A_2 limestone is imperfectly known. At Hood Island the B_1 limestone is probably cut out by the fault at the base of the Windsor section. Although the B_1 limestone is not exposed in the Mabou-Judique map-area, it outcrops at Lake Ainslie, a short distance to the north. At Cape Dauphin the interval immediately above the B_1 limestone is covered, and higher beds in the B zone are poorly exposed. The thick gypsum member which is exposed at Hood Island may be absent at Cape Dauphin.

In the Lower Windsor beds along the Southwest Mabou River, salt springs are frequently found. The thick salt mass found in the deep wells drilled near Southwest

Mabou Post Office has already been mentioned. In recent core-drilling east of Antigonish harbor, salt beds about 200 feet thick were encountered in Lower Windsor strata. The stratigraphy of that area is at present being investigated by N. M. Sage, Jr.

At present not enough data are available to determine the detailed sequence between the A₂ limestone and the thick gypsum member in the B zone. The writer's best guess is that the relationship in the Judique-Mabou-Lake Ainslie area is as follows:

Lower Windsor group (Zone B)

+350' Gypsum (exposed on Hood Island).

+200' Salt.

? Maroon siltstone.

+40' B₁ limestone.

Lower Windsor group (Zone A)

? Maroon siltstone.

20 to 60' A₂ limestone ("Canary").

10 to 100' Maroon siltstone.

30 to 50' A₁ basal limestone ("Ribbon").

Horton group.

The limestone members of Zone A are exposed in a small creek which crosses Route 19 at a point three-quarters of a mile north from Judique Railway Station. The outcrops

are in the bed of the creek about half a mile east of Route 19 and a quarter of a mile north of Hillsdale Road. The section is as follows:

Lower Windsor group (Zone A)

Covered.

5' A₂ limestone. Massive, fine-grained, vuggy limestone resembling a mudstone. Bright yellow colored when fresh, buff and gritty when weathered. No fossils are present.

105' Covered.

6' A₂ limestone. Same lithology as above.

6' Covered.

40' A₁ limestone ("Ribbon"). Hard, thin-bedded, blue-gray in unweathered condition, readily altered to lighter colors by exposure.

Horton group. Fine-grained, platy gray sandstone.

About forty feet of the A₂ limestone is exposed in the bed of Mull River, near the bridge on the Glencoe-Southwest Mabou road. At this locality the limestone is underlain by 100 feet of maroon siltstone, and the upper contact of the limestone is concealed. Good exposures of this member can be seen along the Southwest Mabou River. One and three quarters of a mile north of Upper Bridge, 60 feet of the A₂ limestone is exposed; it is bounded above and below by maroon siltstone.

The section is somewhat complicated by faulting and the complete sequence could not be established.

The best outcrop of the A₁ limestone is found in the bed of the Mabou River, about one mile south of the Hillsborough Post Office. Here the unit is 50 feet thick and is underlain by gray thin-bedded sandstones of the Horton group. The overlying beds are concealed. A few good exposures of the A₁ limestone are seen along the Southwest Mabou River. This limestone is not known to contain fossils but correlation is readily made on the basis of its ribbon-type stratification. The rock is identical with a limestone member found at the base of the Lower Windsor at most localities in Nova Scotia and New Brunswick.

	A	B	C	D	E
FORAMINIFERA					
Nodosinella priscilla (Dawson)		c	cc		
COELENTERATA					
Dibunophyllum lambii Bell					
Unidentified Tabulate Coral					rr
Conularia planicostata Dawson		cc			rr
ANNELIDA					
Serpula annulata (Dawson)		r			
BRYOZOA					
Fenestrellina lyelli (Dawson)		cc			
Septopora primitiva Bell		rr			
Streblotrypa biformata Bell		rr			
Batostomella exilis (Dawson)		cc			rr
Tabulipora acadica Bell					
Unidentified Bryozoan					
BRACHIOPODA					
Schellwienella sp.					c
Productus productus var. tenuicostiformis (Beede)		cc	r		r
Linoproductus lyelli (Verneuil)		cc	c		
Linoproductus lyelli var. a. (Bell)		cc	r		r
Linoproductus semicubicalus (Bell)					
Avonia ? sp.		rr			
Pugnax dawsonianus (Davidson)		c			
Pugnax magdalena (Beede)		rr			
Shumardella ? sp.		rr			
Spirifer ? sp.					
Ambocoelia ? acadica Bell					rr
Martinia galataea Bell			c	cc	c
Martinia thetis Bell				r	
Composita dawsoni (Hall & Clarke)		c			
Composita windsorensis Bell		c			
Composita obligata Bell		rr			
Spiriferina verneuii Bell		r			
Punctospirifer sp.		rr			
Beecheria davidsoni (Hall & Clarke)		cc	c		r
Beecheria latum (Bell)		cc	c	r	
Beecheria milviformis (Bell)		c			
Cranaena tumida Bell		c			
Romingerina anna (Hartt)		r			
PELECYPODA					
Sanguinolites parvus Bell		c			
Sanguinolites striatogranulatus Hind		rr			
Edmondia rudis McCoy		r			
Grammatodon (Parallelodon) hardingi Dawson		cc			
Grammatodon (Parallelodon) dawsoni Beede		c			
Leptodesma borealis Beede		rr			
Leptodesma acadica (Beede)		rr			
Schizodus cf. S. denysi Beede					cc
Aviculopecten lyelli Dawson		cc			
Aviculopecten lyelliformis Bell		rr			
Aviculopecten subquadratus Bell		r			
Pseudamusium simplex (Dawson)		rr			
Lithophaga poolii (Dawson)		c			
GASTROPODA					
Stegocoelia abrupta (Bell)			cc		
Stegocoelia compactoidea (Bell)		r			
Flemingia (Anematina) dispersa (Dawson)			r		
Naticopsis howi Dawson		c	r		
CERPHALOPODA					
Diodoceras avonensis (Dawson)		c		r	
Stroboceras hartti (Dawson) ?		rr			

* Upper Windsor, zone doubtful.

cc Abundant
c Common
r Scarce
rr Rare

	R-1	R-2	V-3 L.	V-3 U.	V-1	V-2	I-1	I-4	I-5	V-4	I-6	I-2	I-3
FORAMINIFERA													
Nodosinella priscilla (Dawson)			X				X						
COELENTERATA													
Dibunophyllum lambii Bell									X		X		
Unidentified Tabulate Coral							X						
Conularia planicostata Dawson	X	X	X	X	X			X		X			
ANNELIDA													
Serpula annulata (Dawson)	X	X											
BRYOZOA													
Fenestrellina lyelli (Dawson)	X	X	X					X					
Septopora primitiva Bell								X					
Streblotrypa bifurcata Bell	X												
Batostomella exilis (Dawson)	X	X	X	X	X			X		X			
Tabulipora acadica Bell										X			
Unidentified Bryozoan						X							
BRACHIOPODA													
Schellwienella sp.				X									
Productus productus var. tenuicostiformis (Beede)	X	X	X	X	X			X	X	X			
Linoproductus lyelli (Verneuil)	X	X	X		X					X			
Linoproductus lyelli var. a. (Bell)	X	X	X	X	X		X		X	X			
Linoproductus semicubicalus (Bell)						X							
Avonia ? sp.	X												
Pugnax dawsonianus (Davidson)	X	X	X		X					X			
Pugnax magdalena (Beede)	X	X			X								
Shumardella ? sp.	X												
Spirifer ? sp.						X							
Ambocoelia ? acadica Bell				X									
Martinia galataea Bell				X		X	X					X	X
Martinia thetis Bell							X						
Composita dawsoni (Hall & Clarke)	X	X	X					X		X			
Composita windsorensis Bell	X							X					
Composita obligata Bell	X												
Spiriferina verneuili Bell	X	X											
Punctospirifer sp.	X												
Beecheria davidsoni (Hall & Clarke)	X	X	X	X	X		X	X	X	X			
Beecheria latum (Bell)	X	X	X		X			X		X			
Beecheria milviformis (Bell)	X	X	X		X					X			
Cranaena tumida Bell	X		X		X								
Romingerina anna (Hartt)	X	X	X		X			X		X			
PELECYPODA													
Sanguinolites parvus Bell	X	X			X			X					
Sanguinolites striatogranulatus Hind	X												
Edmondia rudis McCoy	X	X											
Grammatodon (Parallelodon) hardingi Dawson	X	X											
Grammatodon (Parallelodon) dawsoni Beede	X	X											
Leptodesma borealis Beede		X											
Leptodesma acadica (Beede)		X			X					X			
Schizodus cf. S. denysi Beede							X					X	
Aviculopecten lyelli Dawson	X	X	X		X			X		X			
Aviculopecten lyelliformis Bell	X									X			
Aviculopecten subquadratus Bell	X				X								
Pseudamysium simplex (Dawson)					X								
Lithophaga poolii (Dawson)		X	X		X					X			
GASTROPODA													
Stegocoelia abrupta (Bell)							X		X				
Stegocoelia compactoidea (Bell)		X	X					X					
Flemingia (Anematina) dispersa (Dawson)							X						
Naticopsis howi Dawson	X	X	X		X		X	X					
CEPHALOPODA													
Diodoceras avonensis (Dawson)	X						X						
Stroboceras hartti (Dawson) ?	X												

Figure 5. Geographic distribution of Windsor fauna.

CONDITIONS OF DEPOSITION

In the correlation or noncorrelation of strata, much importance is given to the factor of environment for both sediments and organisms. Twenhofel (1931:424) observed that "correlation on the basis of fossils alone is not entitled to a great deal of respect". The paleoecologist has few materials indeed from which to reconstruct past environments. Usually the records consist only of lithologic and stratigraphic evidence and the data supplied by the attitude and character of the fossils themselves. Admittedly the environments indicated by these inadequate data are not necessarily the life environments. Nevertheless there are certain unusual features of the Windsor faunas that invite speculation on the possible conditions of burial.

The thick monotonous sequences of red beds in the Windsor make up about 70 percent of the whole, and in addition there is much gypsum, anhydrite, and some salt. Such an accumulation of evaporites and red beds once was thought to be an infallible indication of aridity, because such deposits are forming today chiefly in desert or semiarid areas. Many recent investigators believe that such an accumulation may be controlled by structure rather than climate (Garrels, 1951:399). The predominance of silt and clay size argillaceous materials and evaporites, and the lack of sandstones

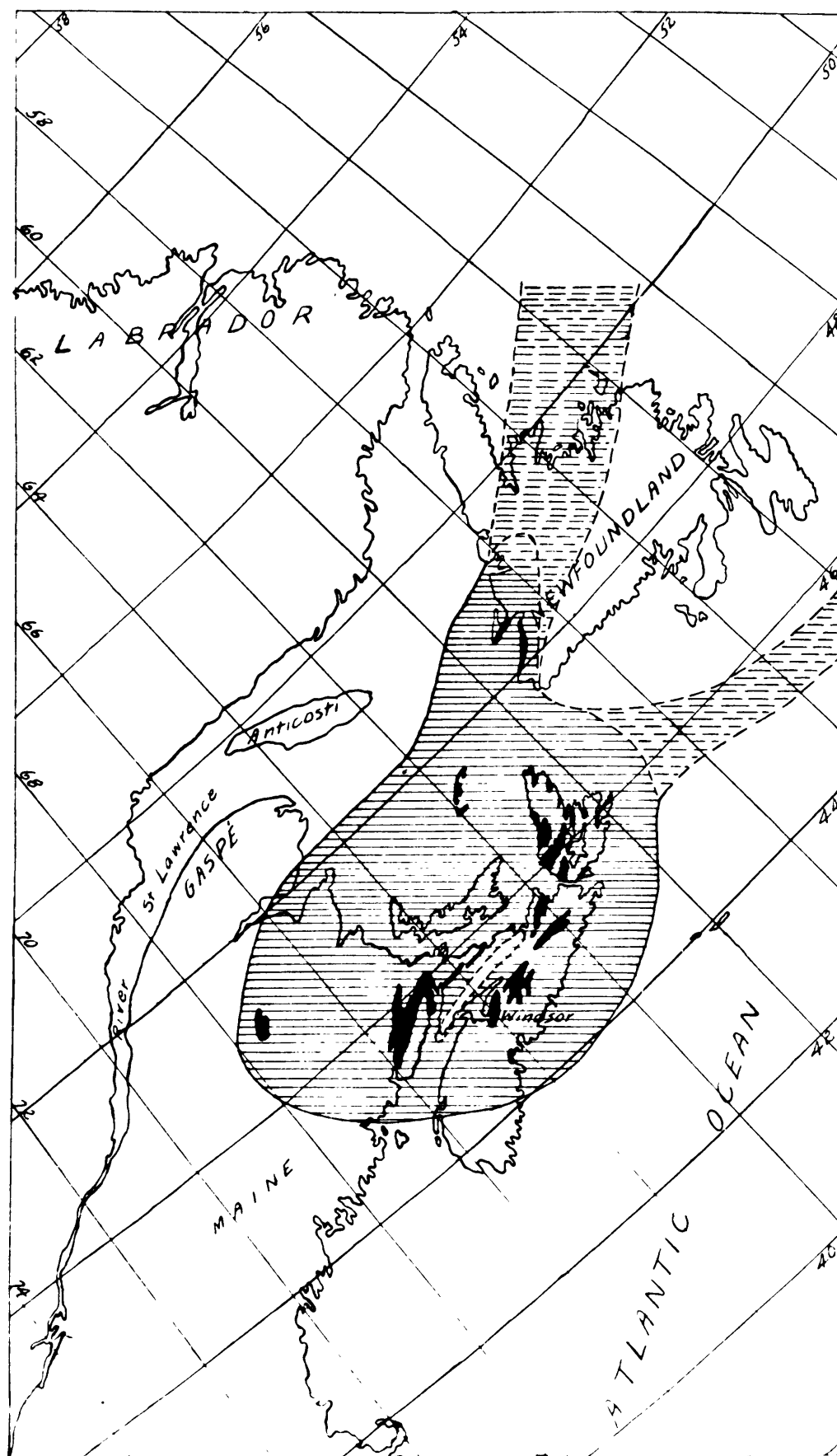


Figure 6. Map showing probable extent of Lower Windsor sea. After Bell.

do not indicate true geosynclinal associations. Neither are the fossiliferous-fragmental limestones typical of geosynclines, unless one postulates that they might have been swept in near the cratonic border. Neither do the Windsor rocks, as a whole, display relatively uniform conditions of sedimentation for long intervals of time, such as might be expected on a shallow submerged continental shelf. Rather, there seems to be a complex of environments: a shallow-water offshore environment, a restricted basin type, and a deeper water, open basin environment where the bottom sediments are mainly red oozes.

The rate of subsidence in the depositional area depends on the part of the basin one is studying. The predominance of stable minerals in the thick persistent clastic members suggests conditions of widespread peneplanation in the hinterland, and deposition in the basin after deep weathering. Evidently the basin floor was quite stable at certain periods; the debris was re-worked and the more unstable minerals eliminated, resulting in the deposition of quartzose siltstones and shales high in iron-oxide. The lack of rich organic muds would seem to imply well aerated quiet areas of accumulation. Periods of greater rate of subsidence resulted in shifting of strand-lines, warping, and deposition of more silty shales.

The lagoonal environment of a hypersaline sea may not be essential to the picture, yet a shallow sea is bound to have some lagoonal features, resulting in restriction of circulation

at times and deposition of extensive sheets of evaporites. Lagoonal areas might well become a haven for relics of a normal marine fauna that could exist under the rather difficult conditions of environment. Streams draining the arid lands bordering the relic sea, although few in number, would effectively reduce the salinity of the water along the coast bordering the stream mouths.

The individual limestones as a whole are typically tabular bodies, relatively thin and widespread, suggesting conditions of slow submergence as the trough came to isostatic adjustment. That most of the limestone deposition took place under shallow-water conditions is borne out by the widespread distribution of algae, which required light for photosynthesis. Based on the considerable knowledge of shallow water biology, the faunal assemblage suggests deposition in not more than 500 - 600 feet of water.

The marked unconformity found locally between the Horton and Windsor represents a period of erosion and subsequent sea invasion. The effects of some movement during early Windsor time is reflected in southeastern Cape Breton where conglomerates become locally important, and the B and C zones transgress on pre-Mississippian rocks. Impure, ribbon-banded, unfossiliferous limestones are the dominant type of A₁ sediment. This great sheet of limestone stretches almost continuously from New Brunswick to eastern Cape Breton and reflects a clearing of the waters as the inundation reached

its maximum quite early in Windsor time. Above the A₁ in the Lower Windsor, the succeeding limestones tend to be dense and occur in massive strata. At this stage the currents became weaker, presumably in accordance with a slight deepening of the seas.

During most of Windsor time in Cape Breton conditions did not favor invertebrate life, but at the base of the B zone brachiopods, mollusks and gastropods became established and their remains constitute the extensive fauna of the B₁ limestone. Similarities in megascopic fauna and lithology in the B₁ zone suggest that throughout the Maritime region this horizon probably formed under conditions of stability. There are here criteria which indicate that the typical B₁ fauna is a natural one, little if any affected by mechanical sorting of the shells, for the young and adults are found together, and the association as a whole is not unlike that found in many typical shallow water biostromes of the Mississippian. The shells are deposited in a heterogeneous fashion with no traces of bedding planes, and the state of preservation in the material is remarkable. The delicate zoaria of the fenestellids are intact, and they often bind brachiopods, mollusks and other shelly debris into tangled masses. Streblotrypas are invariably found encrusting the outsides of closed brachiopod valves. The terebratulids and spiriferids are commonly found with the valves closed, the interiors

hollow, and the loops and spires entire. Evidently the shells were not exposed to muddy water, else foreign material would have entered the interiors through the pedicle openings. Many of the conularids are undistorted, essentially complete, and some are apparently in the position of growth; the fillings of the interiors usually contain other fossils. Even the pelecypods are found in a bivalve condition.

Twenhofel (1931:424) suggested that excellent preservation of benthonic organic material implies a rather delicately balanced situation which probably was the exception and not the rule. Slow deposition under ordinary conditions in shallow oxygenated waters gives a most favorable environment for organisms, but at the same time extremely favorable for scavengers with resultant elimination and disappearance of organic matter. Too rapid deposition renders a bottom inhospitable for organisms, but favorable for their entombment and preservation. Conditions somewhere between these two extremes would seem to provide the best environment for the accumulation of the prolific, well-preserved fauna of this member.

The radical change in the composition of the fauna above the B₁ limestone indicates a very different set of environmental conditions. For reasons still not understood, thick beds of salt and gypsum accumulated in most of the basin areas of the Maritime region. Boundary conditions may have

been such as to achieve near-isolation of the Windsor seas during this period. The succeeding limestones in the middle third of Windsor time are commonly algal or oolitic, and they are sparsely fossiliferous until the C₃ horizon is reached. The C₃ beds form an ecological assemblage reminiscent of a small bioherm, owing its origin to the alga-anchorage afforded by the large conical algal columns found in the deposit. It appears that the algal columns grew in shallow disturbed waters, with fossils and lime mud swept among them by the currents. An abundance of minute gastropods, ostracods, brachiopods and other organisms lived in the crevices and cavities of the algal-bank. Many specimens found here are small gibbous variants of Beecheria davidsoni. The structures of the beak and large foramen of the species indicate a strong functional pedicle, necessitated by the current in which these brachiopods lived. The first Windsor corals appear in the C zone, and in view of their extreme sensitivity to turbidity it is not surprising that they are rare.

In the D₁ limestone brachiopods and cephalopods were concentrated on the sea-floor by currents, a view supported by the coarse oolitic matrix and the strongly waterworn fossils found throughout the vertical extent of this member. As might be expected, types found in this oolitic facies often attain maximum size and weight, hence were probably capable of withstanding strong wave or current action. Martinia galataea are abundant, all with the disconnected

valves worn, often fragmental, and generally lying convex upwards. The shells were quite clearly buried on bottoms removed from the sites where the organisms lived. Nautiloid cephalopods were largely benthonic shallow water organisms, though with some exceptions. They were, to a large extent, restricted in environmental range. The appearance here of a few shells of Diodoceras is probably to be interpreted as the transportation after death of floating shells, buoyed up by gas within the camerae, until breakage or solution of the shell allowed the gas to escape, and permitted the shell fragments to sink, become buried and preserved in the sediments of a foreign environment. At most localities the upper part of the D₁ limestone contains ripple marks developed on a relatively large scale, with wave lengths averaging 20 inches and amplitudes of 4 inches. They are typically symmetrical in transverse profile and the crests are remarkably straight and parallel over large areas. Bucher (1919:170) believes that para-ripples in which coarse and fine materials are evenly distributed are formed by currents set up in shallow open seas by tides and storms such as tropical hurricanes. He suggests that they could not have developed in depths in excess of 25 meters. These structures are apparently widespread in this particular limestone, having been observed in the Antigonish area. Other facts agree with conclusions that these seas were shallow. It may have been that they were, at least periodically, disturbed by violent storms, possibly

tropical hurricanes. The beds evidently formed nearer to the shore. The turbulent conditions which resulted were not suitable to many of the organisms which lived in comparatively quiet seas.

Except for the pelecypod Schizodus, fossils are rare in the E₁ dolomite beds. Pelecypods were probably less sensitive to rapid changes in environment than the other invertebrates, hence they were able to thrive under more adverse conditions. Corals are characteristic of this horizon at the type locality, but in Cape Breton they are represented by a single species, which is rare. Near the top there is a thin lean layer with varied brachiopods, but the shells are seldom of normal size or well-preserved. Many of the more fragile forms were apparently crushed and **broken** into fragments. The less fragile shells have the appearance of having been subjected to abrasion, which removed their finer markings. The presence of fine arenaceous material in these dolomites, as well as lenses of cross-bedded oolitic material and patches of comminuted brachiopod shells, and transportation which the shells and tests apparently underwent, attest the shallowness of the sea and the probable influence of shifting littoral currents.

Following the deposition of the E₁ dolomite, true marine conditions with brachiopods, bryozoa and/or crinoids as evidence have not been recorded. Clastic sedimentation

becomes relatively more important and the succeeding beds in zone E show remarkable lateral variations. A few thin algal bands appear near the top of this zone, and the obscure Windsor-Canso contact marks the complete annihilation of the Windsor fauna. Land plant debris is found at some levels in the basal Canso and there are occasional strata bearing brackish-water mollusks and crustaceans to record the withdrawal of the sea.

CORRELATION

Viséan faunal zones have now been traced from the mainland of Europe through England, Ireland, and Greenland to Newfoundland and Nova Scotia. Important elements of the Visean fauna had avenues of migration, however roundabout, even as far as Texas and Oklahoma (Miller and Youngquist, 1948:651). The faunal evidence at the Windsor type locality has been admirably summed up by Bell (1929:71-73) and the middle and late Viséan age of the Windsor group has been well established (Lewis, 1935:120-122). Easton (1943:127) thinks that "the faunal list of the Windsor of Canada is of decided European character, but correlations with the Chester of the Mississippi Valley seem of doubtful validity. It does not seem likely that the fauna of the Windsor sea ever entered the mid-continent sea of the United States. Instead, the Windsor appears to be typical of European Carboniferous seas". Hill (1948:143) notes that "an Upper Viséan (D zone) fauna of impoverished European type occurs in Nova Scotia with Dibunophyllum, Caninia, Triplophyllites, Bothrophyllum, Koninckophyllum, and phaceloid Lonsdaleia".

Enough specimens have been obtained during the present investigation to suggest that the five faunal zones of the type section, and of the Cape Breton area (1) occupy the same stratigraphic positions, (2) have similar facies

relationships, and (3) contain generically and specifically comparable suites of fossils. Therefore they are considered essentially contemporaneous. Species which Bell considered critical for the identification of the five faunal zones at Windsor are as follows (1929:46):

Upper Windsor. Zone with Martinia galataea.

Zone E. Caninia dawsoni and Chonetes politus.

Zone D. Linoproductus semicubculus.

Zone C. Dibunophyllum lambii and Nodosinella priscilla.

Lower Windsor. Zone with Composita dawsoni.

Zone B. Diodoceras avonensis.

Zone A. Basal limestone.

All of these diagnostic forms except two (Caninia dawsoni, and Chonetes politus) are represented in the present collection taken from Cape Breton Island. The corals are not as well preserved or abundant as are those in Windsor. The fact that the diagnostic species Diodoceras avonensis is not confined to the B zone in Cape Breton Island, lessens its importance as an indicator of that unit. By examining the records given in the accompanying faunal chart, it may be noted that the assemblage in the present collection contains fewer species than that given in Bell's table for the type area (1929:66). This difference could be due to different methods of collecting

care in identification, exigencies of preservation, differences in ecology, and so on.

The A zone beds generally have been regarded as barren of organic remains, and the correlation with Bell's A subzone is based on the characteristic laminated "ribbon" limestone at the base, and its stratigraphic position in relation to the overlying main fossil member of the basal B zone.

The B₁ limestone in Cape Breton Island contains representatives or close counterparts of almost all of the species in the type locality, and there is no doubt that they are contemporaneous. The gastropods, in particular, have a more restricted occurrence than in the Maxner-Miller limestone at Windsor.

The base of the Upper Windsor is assumed to be the lowest limestone carrying Martinia galathea, the C₁ limestone. In the areas studied the assemblage of C zone species is unique as an indicator of a horizon. With some slight allowance for variability the same species are easily recognized in both faunas, and the shallow water aspect of the assemblage is strikingly like that at Windsor. Although the guide fossil Dibunophyllum lambii is not present in either the Hood Island or Cape Dauphin sections, it was collected in fair quantities at Lake Ainslie and at Grand-Etang.

The small faunal list of the D zone in Cape Breton Island is contradictory and inadequate. The diagnostic fossil Linoproductus semicubicalus is abundant in a certain horizon at Middle River, which is believed to be in the D zone, but undoubted specimens of this species have not been found elsewhere in the Cape Breton area. Martinia galataea which is an abundant form at Windsor, is found in great quantities in the D zone of Cape Breton Island.

Although Bell's key fossils Caninia dawsoni and Chonetes politus are missing from the E zone in the Cape Breton region, it shows a mingling of types which indicates that similar ecologic conditions applied to both areas. Schellwienella sp. and Ambocoelia? acadica occur here but are not common enough to serve as a very good basis for zonation. The E₁ dolomite is characterized by an abundance of Schizodus cf. S. denysi. Some unidentified brachiopods and a tabulate coral are also present. In Cape Breton Island the E zone must be recognized by its distinctive biologic assemblage. Although it has less in common with the fauna of the type locality, the features are ones that would be subject to environmental control and suggest a facies relationship with the E zone at Windsor.

SUMMARY. The faunal differences between the type area and Cape Breton Island, never very great, are due largely to the chance preservation of the rarer elements, which actually constitute a considerable portion of the rather imposing faunal lists already on record.

Bell's faunal zones appear to be applicable regionally, and form well defined zones having stratigraphic usefulness in the Cape Breton area. The division between the Lower and Upper Windsor is probably logically drawn, despite the fact that the most striking paleontological break occurs lower in the column. Each zone has a definable top and bottom on the basis of limiting hiatuses and lithologic changes, and the faunal assemblages from the various zones are distinctive and can be readily separated. The faunal zones represent definite depositional environments and are of wide geographic extent. The present writer sub-divided the faunal zones A-E for convenience in local stratigraphic work, but such subdivisions are not applicable on a regional basis.

The upper part of the A zone and the basal relationships of the B zone remain undescribed, so the relative positions in the column of the B₁ limestone, the salt, and the thick gypsum member are uncertain. Until further work is done, particularly sub-surface studies, it is difficult if not impossible to determine whether the various main fossil sub-zones (the B₁ limestones) are stratigraphic equivalents. In a letter to N. M. Sage, Jr., Dr. Bell indicated that the

Maxner and Miller Limestones at Windsor (collectively correlative with our B₁ limestone) might well be contemporaneous beds.

Insufficient corals were collected to determine whether our E zone is strictly contemporaneous with deposits believed to be of the same age in the Windsor district, where the characteristic coral is Caninia dawsoni. Nevertheless, a study of the remainder of the fauna in the E zone indicates that the similarities between the faunas of these two localities are more significant than the differences, and a facies relationship is suggested.

FOSSIL LOCALITIES

(Each locality consists of a number preceded by the first letter of the county in which the collections were made, e.g. I, V and R for Inverness, Victoria and Richmond counties, respectively).

- I-1. Beach exposure on the north shore of Hood Island, beginning at the extreme northwest tip of the island.
- I-2. Beach exposure at Ragged Point, 1.3 miles south of intersection of Shore Road and Route 19.
- I-3. Beach exposure at Kate Point, 1.5 miles south of locality I-2.
- I-4. Beach exposure, north shore of Lake Ainslie near Doherty Cove, 0.65 miles due east from outlet of Dunbar Brook.
- I-5. Beach exposure, west shore of Lake Ainslie, 0.60 miles northwest from Lake Ainslie Chapel.
- I-6. Abandoned limestone pit; proceed north from village of Grand-Etang one mile to road intersection; proceed one mile due east on side road; pit is located in farm pasture about 2000 feet southeast of Big Lake.
- R-1. Small abandoned quarry, locally called Johnstown Quarry, in road cut on south side of St. Peter's Road, about 1000 feet east of Johnstown Magazine.
- R-2. Limestone bluffs in river bank at Irish Cove, 200 feet south of St. Peter's highway bridge over Irish Brook.

- V-1. Limestone exposure in road cut 0.75 miles south of Middle River Settlement, on the Baddeck Road.
- V-2. Massive limestone ledges in bed of Middle River, about 100 feet north of bridge over Middle River, at Middle River Settlement.
- V-3. Beach exposure at extreme northeast tip of Cape Dauphin. (V-3L. identifies Lower Windsor and V-3U., Upper).
- V-4. Beach exposure at Dingwall, on the south shore of Aspy Bay, 3.4 miles west of White Point at inlet to South Pond.

DESCRIPTION OF GENERA AND SPECIES

Bell's memoir (1929) contains descriptions and illustrations of 132 Windsor species of which 49 are represented in the collections now under study. Inasmuch as Bell's publication is available to most students, the descriptions of some forms are not repeated here.

PHYLUM PROTOZOA

Order FORAMINIFERA

Genus Nodosinella Brady 1876

Nodosinella priscilla (Dawson)

Plate I, fig. 1

Dentalina priscilla Dawson, 1868, p. 285, fig. 82.

Nodosinella priscilla Brady, 1876, p. 105, pl. 7, figs. 8-9.

Nodosinella priscilla (Dawson), Bell, 1929, p. 90, pl. 1, fig. 3

Distribution: Mississippian, Windsor group of Nova Scotia. Abundant at the base of the C₃ limestone on Hood Island; common at the top of the B₁ limestone at Cape Dauphin. Bell used this species to characterize the C zone at the type locality.

PHYLUM COELENTERATA

Class ANTHOZOA

Subclass TETRACORALLIA

Genus Dibunophyllum Thomson and Nicholson 1876

Dibunophyllum lambii Bell

Plate I, figs. 2-4;

Plate II, figs. 1-4

Dibunophyllum lambii Bell, 1929, p. 95, pl. 4, fig. 1-3;

Lewis, 1935, pp. 137-138, pl. 7, fig. 7-8b.

Discussion: Bell and Lewis have given full descriptions, with figures, of this coral. The specimens in the present collection have the characteristic central column constructed of the portions of some of the major septa, and of tabellae rising sharply to a median lamella derived from the counter-septum. There are several specimens in the collection. External markings and calyx were not seen. The most complete example is cylindrical, slightly curved at the proximal end, about 40 mm. long and 14 mm. in greatest width. The characters of the longitudinal section are poorly shown in the figure.

Distribution: This species characterizes the C zone at the type locality. Some of Lewis' specimens came from the New Glasgow district and he states: "This appears to be the first record of its occurrence in the northern basin, and another point of interest from the standpoint of correlation is that the locality appears to be that at which the only

known specimens of Lonsdaleia pictoense Billings were discovered". One group of the writer's specimens came from an isolated outcrop at locality no. I-5, where they occur with Productus productus var. tenuicostiformis and Beecheria davidsoni. The second group, containing about 30 specimens, was collected at locality no. I-6. The precise stratigraphic position within the Upper Windsor could not be determined at either location.

Unidentified Tabulate Coral

Plate III, figs. 1-3

Description: Corallum colonial and massive, apparently roughly hemispherical, radius about 40 mm, base apparently covered by epitheca. Internal region compact with corallites closely crowded, perpendicular to bedding plane, in what is probably position of growth. Corallites 0.3 to 0.4 mm. in diameter, reaching a length of 17 mm.; cross-section not seen. Walls are thick and so completely crystallized that it is impossible to tell whether they were perforated or amalgamated. Tabulae rather numerous, situated at irregular intervals, slightly arched and disposed horizontally. Peripheral region obscure.

Discussion: Only one incomplete corallum was collected. It is embedded in matrix, therefore the surface is obscured. It is too poorly preserved for identification as to genus, but since a tabulate coral has hitherto not been recorded from Nova Scotia, it seemed worthy of description

and figures. The small dome-like mass was broken in such a way that a natural vertical section was revealed. The figure shows it before sectioning. A microscopic section parallel to this surface was obtained. Figures of the thin sections are of little value because they show the calcite more plainly than the real structure. The essential features can be seen better under the lens from smoothed surfaces slightly etched with acid. Other colonies apparently of about the same dimension are exposed along the bedding planes where the collections were made. Unfortunately crystallization had destroyed all of the detail on these examples.

Distribution: Mississippian, Upper Windsor group of Cape Breton. The single specimen in the collections came from Hood Island, about 14 feet above the base of the E₁ dolomite.

Class SCYPHOZOA

Group CONULARIDA

Genus Conularia Miller 1818

Conularia planicostata Dawson

Plate IV, fig. 1

Conularia planicostata Dawson, 1868, pp. 307-308, fig. 117;
Bell, 1929, pp. 98-100, pl. 32, figs. 1-2.

Description: Shell of large size, elongated pyramidal, tapering regularly; cross-section square throughout. Faces

equal, flat or slightly convex; apical angle about 7°. Marginal grooves linear, of medium depth, rather wide (0.7-0.8 mm.); edges sharply rounded; the bottoms V-shaped and filled with the ends of the transverse ridges. A straight slender segmental longitudinal line occurs in the middle of each face, appearing as a blackish streak. It indicates an internal septal structure, apparently rising from the inner shell layer without disturbing the contour of the exterior. This mid-line influences the course of the transverse ridges, for the ridges alternate toward the large end of the shell; apically they are opposite.

On the internal mold the surface has transverse ridges with thin sharp threadlike crests and wide, shallow smooth furrows; 13, 7 and 5 of these ridges occur in lengths of 5 mm., taken near the apex, at the middle of the shell, and near the larger end, respectively. The ridges are arched towards the aperture, more abruptly at the mid-line of the face; they are not deflected on crossing the shoulder of the marginal grooves. The ill-defined apertural end of one specimen is constricted by an incurved lobe; apex unknown. Only one layer of test appears on the Cape Breton forms, although Bell reports a test of four layers on one of the specimens from Windsor. The oblique striations on the transverse ribs, which Bell mentions, are only seen under high magnifications and good conditions of lighting. Most complete specimen is 70 mm. long with a facial width of 12 mm. at the larger end.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Common and widespread in the B₁ limestone, rare in the E zone; collected at localities R-1, R-2, V-1, V-3, V-4, and I-4.

PHYLUM ANNELIDA

Genus Serpula Linnaeus 1746

Serpula annulata (Dawson)

Plate IV, fig. 2

Serpulites annulatus (Dawson), 1868, p. 312, fig. 131; Bell, 1929, p. 97, pl. 5, figs. 1-1a.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rare; collected only from the B₁ limestone at localities R-1 and R-2.

PHYLUM BRYOZOA

Order CRYPTOSTOMATA

Genus Fenestrellina d'Orbigny 1849

Fenestrellina lyelli (Dawson)

Plate IV, figs. 3-4

Fenestella lyelli Dawson, 1868, p. 288, figs. 86a-c; Bell, 1929, p. 101, pl. 6, figs. 3-5, pl. 7, fig. 3, pl. 8, fig. 2.

Discussion: This species is recognized on the basis of a flabellate zoarium, celluliferous on the inner side. Branches connected at regular intervals by dissepiments and

bearing two rows of zooecial apertures which are separated by a tuberculated median keel (carina). The Cape Breton specimens have a meager development of tubercules; otherwise they agree perfectly with Bell's illustrations.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This species is abundant where the B₁ limestone is exposed, and is most prominent in the lower third of that member. Collections from following localities: R-1, R-2, V-3 and I-4.

Genus Septopora Prout 1859

Septopora primitiva Bell

Plate IV, fig. 5

Septopora primitiva Bell, 1929, p. 102, pl. 6, fig. 6, pl. 7, figs. 1-2, pl. 8, fig. 1, pl. 9, figs. 1-4.

Discussion: McFarlan (1942, p. 454) has given a synopsis of the Chester species of Septopora. The Nova Scotia forms would fall in his Group 2, which is characterized by the addition of new branches chiefly by dichotomy. It is of interest to note that this group is unknown above the Chester. McFarlan cites S. similis from the St. Louis Limestone of Missouri as being the only species of Septopora found below the Chester.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The two specimens in the collections came from the B₁ limestone at locality I-4.

Genus Streblotrypa Ulrich 1890

Streblotrypa biformata Bell

Plate IV, fig. 6;

Plate V, fig. 1

Streblotrypa biformata Bell, 1929, p. 104, pl. 13, figs. 5-6, pl. 14, figs. 1-1a.

Discussion: This species is extremely rare in the collections studied, being represented by a single fragmentary zoarium. It is identical with the specimens which the writer collected at Windsor.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The single specimen in the collections came from the B₁ limestone at locality R-1.

Order TREPOSTOMATA

Genus Batostomella Ulrich 1882

Batostomella exilis (Dawson)

Plate V, figs. 2-5

Stenopora exilis Dawson, 1868, p. 287, fig. 85a.

Batostomella exilis (Dawson), Bell, 1929, pp. 102-103, pl. 11, figs. 1-3, pl. 12, figs. 3-4.

Discussion: The Cape Breton specimens compare closely in size and internal characteristics to the forms described by Bell. An average of 8 zooecia occur in 2 mm. of distance in tangential section.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This is the most prolific bryozoa species in

the Windsor of Cape Breton. It is found in the B₁ limestone where it is abundant and widespread throughout that member. Collections from localities R-1, R-2, V-1, V-3, V-4 and I-4.

Genus Tabulipora Young 1883

Tabulipora acadica Bell

Plate VI, fig. 1

Tabulipora acadica Bell, 1929, p. 105, pl. 10, figs. 1-5.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. This species appears in the collections from one locality, no. V-4, where it is rare. It is associated with unidentified rugose corals. Its exact stratigraphic position in the Upper Windsor is not known.

Unidentified Bryozoan

Plate VI, fig. 2

Description: Zoarium is a branching lacelike structure in the shape of a frond; figured specimen about 7 mm. across. Fenestrules roughly hexagonal but variable in outline, 11 to 12 in 2mm. The branches seem to be broken along a tangential plane; they are slender and zigzag. Dissepiments expanding slightly at their junction with the branches, width equal to or slightly less than the width of the branches. No traces of the zooecia appear on the specimens. Reverse of zoaria was not seen.

Discussion: Only two incomplete fragmentary specimens were collected, and although they are largely imbedded in matrix the structure of the branches and dissepiments are plainly visible. Identification, from frond characters, could not be made in the material studied.

Distribution: Mississippian, Upper Windsor group of Cape Breton. The two specimens in the collection came from locality V-2 where they are found with Linoproductus semi-cubculus.

PHYLUM BRACHIOPODA

Orders PROTREMATA-TELOTREMATA (undifferentiated)

Superfamily STROPHOMENACEA

Genus Schellwienella Thomas 1910

Schellwienella sp.

Plate VI, fig. 3;
Plate VII, figs. 1-2

Description: Shell large, moderately to slightly resupinate; hinge line straight, about equal to greatest width. Measurements of the most complete specimen are: length about 40 mm.; width 50 mm. (one side restored); thickness 8 mm. at hinge line. Pedicle valve resupinate or gently convex, swollen in umbonal region. Beak short, pointed, slightly projecting. Ventral interarea low and flat, about at right angles to the plane of valves, with division into two regions; secondary area bordering pedicle valve is marked by closely spaced vertical

striae. Delthyrium completely closed by a convex deltidium. Valve exterior with straight equidistant closely spaced thread-like radial costellae, with relatively broad, shallow inter-spaces; mature specimen with nine costellae per 5 mm. at anterior margin. Interspaces crossed by regular transverse equidistant narrow-rounded rugae of equal size, closely spaced, and set at right angles to the radial markings; about 15 rugae in 5 mm. Interior with short divergent dental lamellae. Brachial valve imperfectly known.

Discussion: The shell wall of this species is thin and commonly shows distortion; it is difficult therefore to determine the convexity of the valves. As usual in the genus the specimens in the collection vary somewhat in size, shape, width and convexity. The genus is closely allied with Schuchertella but differs in that the latter lacks dental lamellae. In the original description of Schellwienella kennetcookensis Bell states (1929, p. 108): "internal characters unknown, and reference to Schellwienella is based on the strong resupinate character". Stainbrook (1943, p. 42) and others have placed resupinate species in Schuchertella. The conclusion can hardly be avoided that Bell's generic identification of Schellwienella kennetcookensis was not fully established. Various investigators have noted that Schellwienella generally does not possess many outstanding characteristics which enable one to readily distinguish various species unless specimens are completely and exception-

ally well preserved. The Cape Breton specimens are probably conspecific with the forms figured by Bell (1929, p. 107, pl. 15, figs. 5-6). Nevertheless the Nova Scotia forms are not well enough preserved to justify specific designation.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. The species is found at only one locality, where it is relatively common in the E horizon, about 300 feet below the top of the Windsor. Here it is associated with Martinia galataea and Ambocoelia? acadica. Collected at locality V-3.

Superfamily PRODUCTACEA

Genus Productus Sowerby, emend. Muir-Wood 1928

Productus productus var. tenuicostiformis (Beede)

Plate VII, figs. 3-4;
Plate VIII, figs. 1-3

Productus tenuicostiformis Beede, 1911, p. 164, figs.

Diaphragmus tenuicostiformis (Beede), Bell, 1929, pp. 119-120, pl. 18, figs. 1-11.

Description: Contour of shell resembles that of the parent species; outline subquadrate with straight hinge line extended to form ears. Lateral profile concavo-convex with extended trail and moderately deep visceral cavity. Visceral disk of pedicle valve highly arched with subparallel sides. In mature forms the umbo is tightly incurved over the hinge, and the pedicle valve is rotated about the hinge through an

angle slightly greater than 90° . Pedicle valve with or without faint impersistent sinus. Costae are thread-like with relatively wide interspaces; they do not appear on the ears, which are moderately wrinkled. The ears are sharply demarcated from the unbonal slopes and visceral disk by a narrowly rounded deep sulcus. The ears project laterally like small, slightly convex, triangular platforms. The poorly defined spine bases are confined to the ears. One well preserved form has tiny spine bases arranged in two rows along the cardinal slopes.

Brachial valve almost flat for approximately 10 mm. in front of hinge line, then deflected at a right angle down into the trail, deflected portion about 8 mm. deep. The trail forms more or less subquadrate prolongations of the valves beyond the point of geniculation. The intersection of concentric ribs and costae give a reticulated appearance to inner surface of brachial valve. Impersistent, faint nodular swellings may occur at points of intersection. A marginal ridge is well developed along the hinge. The diaphragm is a flattened border from 1-1.5 mm. in width around the anterior and lateral margins of the brachial valve. It has slightly different sculpture than the adjacent visceral disk - it may be smooth or faintly costate. Shells tend to fracture along a plane just below this plate, which commonly splits off with the visceral disk of the brachial valve. Bifid cardinal process is erect and strong, with an incision in each lobe;

clefts in the lobes do not extend as deeply as the central incision. Base of the process extended anteriorly in a knife-like median ridge, which ends slightly below the center of the visceral disc; muscular attachment lobes on either side of the median ridge, about half-way between the cardinal process and the lower tip of the median septum. No well preserved interiors of pedicle valves were observed. The average specimen in the collections is 17 mm. wide, 10 mm. deep (maximum depth of visceral chamber), 14 mm. long to geniculation, and its trail is about 12 mm. long.

Discussion: Productus is distinguished from other members of the Productacea by the flangelike diaphragm around the margin of the brachial valve. Bell (1929:119) referred the Windsor forms to the genus Diaphragmus. Muir-Wood (1928:35) and Sutton (1938:545) regarded Diaphragmus as a synonym. Despite the findings of Muir-Wood and Sutton, Shimer and Shrock (1944:349) and others later used the name Diaphragmus as in good standing. From the confusion of literature it is difficult to differentiate the two genera. In comparing the European and American forms, M. Gordon, Jr. of the U. S. Geological Survey demonstrated to the writer that the diaphragm of Diaphragmus is formed by several repetitions of the trail of the brachial valve, thus producing a layered effect in the internal structure of the shelly plate, whereas the diaphragm of Productus is a simple shelly deposit, a structureless thickening between the valves.

The construction of the diaphragm and the external characteristics as a whole seem to ally the Windsor forms more closely with P. productus (Martin) than with the American forms. The typical form of P. productus (Martin) is said to attain its maximum in the "Brachiopod Beds" of Viséan D₂ age in Wales (Muir-Wood, 1928, p. 47). Our specimens are distinguished from the British forms by the absence of the curious umbrella-like form developed at the end of the trail. P. derbiensis Muir-Wood, of the Viséan subzone D₂ of England (Muir-Wood, 1928, pp. 170-173, pl. 11) and the Windsor species show a resemblance in the posterior part of the shell in shape and sculpture. However, the British form has a less extended trail and different arrangement of spines.

Distribution: Mississippian, Windsor group of Nova Scotia. This species is abundant and widespread throughout the B₁ horizon, less common in higher horizons; collections made from localities R-1, R-2, V-1, V-3, V-4, I-4 and I-5.

Genus Linoproductus Chao 1927

Linoproductus lyelli (Verneuil)

Plate VIII, Figs. 4-8

Productus lyelli Lyell, 1855, p. 221.

Productus lyelli Dawson, 1855, p. 219, fig. 9.

Productus cora Davidson, 1863, pp. 174-175, pl. 9, figs. 22-23;
Dawson, 1868, pp. 297-298, figs. 98a-b.

Productus (Linoproductus) lyelli Verneuil (Bell, 1929, pp. 111-113, pl. 16, figs. 1-5, 7-8, pl. 14, fig. 1).

Description: Shell thin, of medium size, elongate, narrow, deeply concavo-convex. Greatest width at hinge line, cardinal extremities forming an angle of about 90°. Lateral slopes of pedicle valve nearly vertical in posterior part; umbonal region protuberant beyond the hinge line. Visceral chamber thin, brachial valve strongly and evenly curved to match the pedicle. Surface covered by fine radiating costae, which occasionally increase in number by intercalations. A few specimens have the senile type of sculpture characterized by irregular flexuous costae. Concentric wrinkles faintly developed on the small ears and the umbonal slopes; they are more symmetrical and distinct on the brachial valve. Definite reticulate sculpture is lacking. There are 30 costae in a breadth of 10 mm. at a point about 10 mm. below the umbo. Spine bases few, minute, irregularly spaced along the cardinal margin at the base of the umbonal slopes of the pedicle valve. Brachial valve spineless. Cardinal process is not known. A typical individual measures 25 mm. in length, 20 mm. in width, and 18 mm. in depth of pedicle valve.

Discussion: This genus is characterized by finely costate sculpture. It most closely resembles Dictyoclostus but differs in having less distinct rugae and shorter hinge line. Bell has made detailed comparisons with similar forms (1929:113).

Distribution: Mississippian, Windsor group of Nova Scotia. This species is widespread and abundant in the B₁ limestone, less common in the C₃ limestone. Collections from following localities: R-1, R-2, V-1, V-3 and V-4.

Linoproductus lyelli var. a. (Bell)

Plate VIII, figs. 9-12

Productus (Linoproductus) lyelli var. a. Bell (1929, p. 113, pl. 16, figs. 9-11).

Discussion: The shape of the shell and the convexity of the valves are used in differentiating this form from L. lyelli.

Distribution: Mississippian, Windsor group of Nova Scotia. The species has a wide range both vertically and laterally; abundant in the B₁ limestone, less common in the C₃ and E₁ limestones. Collections from localities R-1, R-2, V-1, V-3, V-4, I-1 and I-5.

Linoproductus semicubicalus (Bell)

Plate IX, fig. 1

Productus (Linoproductus) semicubicalus Bell, 1929, pp. 114-115, pl. 17, figs 4-6a.

Description: Shell small, suboval in outline, about as wide as long, hinge line less than greatest width of shell. Lateral profile concavo-convex. Pedicle valve more strongly

arched over umbonal region, beak small, slightly incurving. Costae are prominent over the entire shell, occasionally increasing by bifurcation. There are 26 costae in a breadth of 10 mm. about mid-length of shell. The large major spines are restricted to the ears, but are not commonly preserved in situ. In perfect specimens they are erect and rise at a high, but not necessarily a right angle, from the shell surface. They are symmetrically developed and as many as 18 prominent spine bases in three rows were counted on one ear. The first row along the cardinal margin contained six spines. The second and third rows, with six spines in each, extend obliquely from the beak to the lateral margins, the last row marking the line of separation of umbonal slope and ear. Spine bases appear as large circular orifices sometimes surrounded by raised rims. In addition to these major spines a few smaller spines are scattered irregularly over the shell. Maximum spine length is 5 mm.

Brachial valve shallowly concave, elevated on the slightly rolled ears. Surface reticulated by intersections of fine concentric striae and relatively coarse costae. Cardinal process not observed. An average specimen measures 15 mm. long, 15 mm. wide, and about 2 mm. in depth of visceral cavity. The shells are in a flattened condition so that the curvature is a function of the preservation. The shells are peculiarly preserved, being chalky white.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. The only undoubted occurrence of this species is at locality V-2, where it is abundant and associated with Martinia galatea. At this location the individual limestone members are highly deformed and faulted, and the author was unable to unravel the structure. However, it is certain that the L. semicubculus beds are in either the C or the D zones.

Genus Avonia Thomas 1914

Avonia? sp.

Plate IX, fig. 2

Description: Shell small, wider than long; hinge line less than greatest width. Dimensions are: length 5.3 mm., greatest width of shell 6.5 mm., length of hinge line 5.7 mm., convexity of pedicle valve 1.8 mm. Pedicle valve not highly arched and with umbonal region only slightly protuberant beyond hinge line. Ears prominent but not sharply defined. Node-like elevations occur over entire shell surface, distributed regularly along broad concentric bands. Spine bases become progressively larger and more prominent toward the anterior margin. Growth lines and incipient rugae developed equally from the ears to the anterior portion but less prominent on the umbone. Internal characters not observed. Brachial valve unknown.

Discussion: This small pedicle valve of unusual nature is tentatively referred to this genus at the suggestion of Dr. G. A. Cooper.

Distribution: Mississippian, Lower Windsor group of Cape Breton. The single specimen in the collection was found in the lower third of the B₁ limestone at locality R-1.

Superfamily RHYNCHONELLACEA

Genus Pugnax Hall and Clarke 1893

Pugnax dawsonianus (Davidson)

Plate IX, figs. 3-11

Rhynchonella dawsoniana Davison, 1863, p. 172, pl. 9, figs. 13-14; Dawson, 1868, p. 294, fig. 93.

Camarophoria? globulina? Davidson (non Phillips), 1863, p. 171, pl. 9, fig. 11a-c; Dawson, 1868, p. 293, fig. 92b.

Rhynchonella evangelina Hartt (Dawson, 1868, p. 299).

Pugnax? dawsonianus Hall and Clarke, 1894, pl. 62, figs. 30-33.

Pugnax dawsonianus (Davidson), Bell, 1929, pp. 124-125, pl. 19, figs. 7-14.

Description: Dimensions of an average specimen: length 8.5 mm., width 9.5 mm., thickness 5.5 mm., width of sinus in front 4.5 mm. Pedicle valve triangular at the beak; the straight sides, 6 mm. long, meeting at an angle of about 110° at the beak; anterior part rounded triangular; valve shallow but with an upturned lip in front. Broad shallow sinus, round-bottomed except for costae, originating about mid-length of pedicle valve; a corresponding fold is present on brachial valve. Interarea obsolete, beak narrow, acute and slightly incurved. Three or four broad low costae originate near the umbo and extend anteriorly in the sinus. Three

to four short low costae on each side of the sinus.

Brachial valve obese, the blunt beak hidden by pedicle overhang, the lingual extension of the pedicle valve penetrates its front nearly to the top. Costae are similar to those on the pedicle valve except that those on lateral slopes are less well defined.

Internal structure is commonly incrustated with calcite, and details of hinge plate cannot be seen. The strong crural plates extend anteriorly for a short distance from the floor of the brachial valve, then bend sharply into the umbonal cavity of the pedicle valve.

Discussion: Considerable variation exists among individuals of this species. There are all gradations between comparatively smooth shells and more costate forms, between relatively gibbous and less convex valves. Inasmuch as the specimens are from the same stratigraphic zone, it is probable that the differences do not mark stages in an evolutionary series.

In most particulars the Windsor specimens are strikingly different from the genotype of Pugnax, which was shown to the writer by Dr. G. A. Cooper. Despite the fact that our species has the typical internal characters of the genus Pugnax, it is referred to that genus with some hesitancy.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This species is found only in the B₁ horizon, is widespread and relatively abundant, especially in the lower

third of that member. Collections from the following localities: R-1, R-2, V-1, V-3 and V-4.

Pugnax magdalena (Beede)

Plate IX, figs. 12-15

Camarophoria? globulina? Davidson (non Phillips), 1863, pp. 171-172, pl. 9, figs. 12-12b; Dawson, 1868, p. 293, fig. 92a. Pugnax magdalena Beede, 1911, p. 166, fig.; Bell, 1929, p. 125, pl. 20, figs. 1-3a.

Discussion: This species is similar in size and form to P. dawsonianus but has a more strongly developed fold and sinus. It is characterized by two strong angular costae on the fold, and by an extremely pronounced anterior deflection which gives the brachial valve a bloated aspect. It has a greater proportional width than the forms figured by Bell, but conforms closely to Beede's specimens. A typical individual measures 6.5 mm. long, 7.5 mm. wide and 5.5 mm. thick.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rare; specimens in this collection from the B₁ horizon at localities R-1, R-2 and V-1.

Genus Shumardella Weller 1910

Shumardella? sp.

Plate X, figs. 1-4

Description: Dimensions of an average specimen: length 8 mm., width 12 mm., thickness 9 mm., width of sinus in

front 6 mm. Shell small, biconvex, subglobular in form with strong sinus and fold occupying entire anterior part. Lateral margins bluntly rounded; shell is broadest posterior to mid-length. Pedicle valve triangular at the beak, the straight sides, 5.5 mm. long, meeting at an angle of about 117° at the beak. Anterior part nearly flat, valve shallow but with a strongly upturned lip in front. Lateral edges projecting, sharp. Sinus begins about 2 mm. from the beak, slightly convex at bottom at first, becoming deep at anterior end and bearing two or three faint costae. Bottom of sinus continues as quadrate linguiform extension almost at right angles to plane of valve. Beak small, projecting, slightly incurved, with minute foramen.

Brachial valve deep; the lingual extension of the pedicle valve penetrates its front to the top, where it is highest. It arches with regular curvature along midline from beak to front, more strongly arched transversely. Fold is strong, elevated considerably above remainder of valve, flattened along the summit, increasing in width and height toward front, bearing three or four broad low costae. Lateral slopes of fold descend abruptly and are nearly vertical at the front. Beak small, concealed; bloated umbonal region may sometimes extend to beak of pedicle valve.

Surface of both valves bearing low broad rounded costae, generally failing to reach umbones, except in sinus and fold. Two faint costae on each lateral slope, may be

nearly obsolete on some specimens. Faint growth striae may occur on antero-lateral slopes.

Discussion: The size, shape, strong fold and sinus are distinctive features, and no close approximation to this species could be found in the literature. It has not been possible to study the internal characters, so there is a possibility of a wrong interpretation of the genus.

Distribution: Mississippian, Lower Windsor group of Cape Breton. Rare; found only in B₁ horizon at locality R-1.

Superfamily SPIRIFERACEA

Genus Spirifer Sowerby 1814

Spirifer ? sp.

Plate X, figs. 5-6

Description: This shell is small for the genus, but large in comparison with the Windsor assemblage as a whole. Pedicle valve gibbous; greatest width at hingeline, with bluntly angular cardinal extremities extending into wrinkled ears. Length of shell about five-sixths the width. Rotund ventral umbo rising well above hinge line; beak heavy, moderately incurved. Well-defined pedicle sinus, subangular and narrow on the umbo, but becoming rounded and widening anteriorly with straight poorly defined edges. Costae bold, subrounded; intercostal grooves angular. Lateral slopes carry ten costae on each, costae of equal size except the last 3-4,

which are smaller. Sinus carries five costae, of which the median one is the strongest; those on either slope of the sinus apparently formed by bifurcation. Growth lines take the form of expanded lamellae; the shell becomes thickened toward the umbo, and the additional layers tend to mask the normal sculpture. Shell matter is exceptionally well preserved and consists of rather coarse fibers oriented obliquely to the radial ribs at a rather constant angle. The shell is semi-translucent and is mottled in various shades of pink, probably representing the preservation of original pigment. The pedicle valve measures 24 mm. long, 30 mm. wide, with a convexity of 11 mm.

Discussion: The description is based on a single specimen, a pedicle valve. Therefore the reference to Spirifer is questionable. The Cape Breton specimen agrees perfectly with Bell's S. nox (1929, pp. 137-138, pl. 22, figs. 10-10b). However, his specimens were imperfect, the internal characters were not described, and the brachial valve was not clearly defined. In short, the Nova Scotia specimens are too poor for precise determination. The study of additional material may subsequently require removal to another genus.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. The single specimen in the collection came from locality V-2, where it is associated with abundant Martinia galataea. Unfortunately the beds at that locality are severely

contorted and the exact stratigraphic sequence could not be determined. It is believed to be the D₁ horizon.

Genus Ambocoelia Hall 1860

Ambocoelia? acadica Bell

Plate X, figs. 7-9.

Ambocoelia acadica Bell, 1929, p. 141, pl. 22, figs. 3-4b

Description: Of four specimens, all are more or less embedded in matrix. The most complete example measures 7 mm. long, 9 mm. wide (restored) and 6 mm. thick. Outline sub-elliptical, profile biconvex, pedicle valve having the greater convexity. Beak blunt, rather heavy, moderately incurved. High, more or less uniformly arched interarea, not set off sharply from the rest of the valve, with growth lines parallel to hinge line. Hinge line about two-thirds the maximum width of the shell. Brachial beak not pronounced, slightly incurved. Shell surface is smooth with a black glassy sheen. Character of spiralia has not been observed.

Discussion: The reference of this species to Ambocoelia is based upon external similarities since the internal characters have not been observed, and Bell did not define them. The Cape Breton specimens are larger than the forms figured by Bell but are almost certainly conspecific with the holotype.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. It occurs at only one locality where it is rare in the E₁ limestone, about 300 feet below the top of the Windsor. Here it is associated with Martinia galataea and Schellwienella sp. It was found at locality V-3.

Genus Martinia McCoy 1844

Martinia galataea Bell

Plate X, fig. 10;
Plate XI, figs. 1-5

Spirifer glaber Verneuil (Lyell, 1845, p. 221; Dawson, 1855, p. 376).

Spirifera glabra Davidson, 1863, p. 170, pl. 9, figs. 9-10.

Spirifera glabra Martin (Dawson, 1868, pp. 291-292, fig. 89).

Martinia galataea Bell, 1929, pp. 142-143, pl. 22, figs. 5-5b, pl. 23, fig. 1-3.

Description: Length of average specimen 19-23 mm., width 20-25 mm., convexity of pedicle valve 8-10 mm. An imperfect pedicle valve collected at Kate Point, Inverness county, measured 31 mm. wide. Shell sub-pentagonal in outline, unequally biconvex, widest across middle; cardinal angles rounded; hinge line straight, with length about two-thirds the width of shell. Pedicle valve strongly and evenly convex, with high incurved umbo rising well above hinge line. Umbonal shoulders diverging at about 105°, and reaching mid-length of shell. Beak is sharp, produced, and incurved;

interarea is high and abruptly arched apically, not set off from the adjoining part of the shell. Open delthyrium with flange-like laminae projecting inward from the delthyrial borders. Sinus not more than 2 mm. deep at the deepest part, greatest width 5 to 6 mm. in average specimens. Surface smooth except for a few weak growth lamellae. Interior of shell shows strong, straight, radiating ribs over its whole surface; they can sometimes be seen by translucence from the exterior. Mature shell has 20 to 22 of these ribs, regular rounded broad crests with narrow deep V-shaped interspaces.

Brachial valve shallow, gently convex; more or less straight posteriorly. Umbo small, blunt, scarcely rising above hinge line. Sculpture as in pedicle valve. Shells are invariably preserved with a nacreous luster.

Discussion: Nothing is known of the character of the brachidia since Bell did not discuss it and the present collection does not include any suitable material. The Cape Breton specimens are all weathered to some extent. The valves are almost always separate, and while many scores of fair pedicle valves were collected, only a single imperfect brachial valve was found. The individuals are rather variable and there are gradational forms between M. galataea and M. thetis. Reed's Martinia (Merospirifer) insolita (1948, pp. 467-469, pl. 10, figs. 6-9) from the Lower Carboniferous of Scotland "seems to be almost identical" with M. galataea, and the two may be conspecific.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. There are large numbers of specimens of this species in the present collections. In Cape Breton it is widely distributed and most common in a zone ranging from 7 to 14 feet above the base of the D₁ member. It is also found in the C and E zones. Collections from the following localities: V-2, V-3, I-1, I-2 and I-3.

Martinia thetis Bell

Plate XII, fig. 1

Martinia thetis Bell, 1929, pp. 143-144, pl. 23, figs. 4-4c.

Discussion: This shell has the typical characters of the genus; hinge-line shorter than the width of the shell, edges of the interarea obtusely rounded, surface smooth, neither dental plates nor septa on the interior. It agrees in all essential features with the holotype in the Ottawa collections. There are gradations that connect this form with M. galataea. However there are abundant individuals that one may group about the mean form of M. thetis, which are readily separable from M. galataea by their more transverse form, longer hinge-line and with umbonal shoulders that diverge at a greater angle - about 115°. M. thetis is closely allied to M. (Merospirifer) disparilis of the Middle Carboniferous Charlestown Main limestone of Fife, Scotland (Reed, 1948, pp. 469-471, pl. 11, fig. 1). If Reed's figure of the holotype

is representative, the Nova Scotia species is slightly more transverse in shape than the Scotch form.

Distribution: Missippian, Upper Windsor group of Nova Scotia. Found only in the D₁ limestone in small numbers, where it is associated with M. galataea, from 7 to 14 feet above the base of that member. Collections from locality I-1.

Superfamily ROSTROSPIRACEA

Genus Composita Brown 1849

Composita dawsoni (Hall and Clarke)

Plate XII, figs. 2-8

Athyris subtilata (non Hall) Davidson, 1863, p. 170, pl. 9, figs. 4-5.

Seminula dawsoni Hall and Clarke, 1894A, pp. 95-96, 364, pl. 47, figs. 32, 34; 1894B, p. 652; 1895, p. 359, pl. 9, figs. 14, 16.

Composita dawsoni Beede, 1911, p. 180.

Composita dawsoni (Hall and Clarke), Bell, 1929, pp. 132-133, pl. 20, figs. 16-23b.

Description: Shell small, biconvex, subovate in outline; length and width sub-equal, greatest width about mid-length. Surface smooth except for fine lines of growth; ventral valve evenly convex longitudinally and transversely, sinuous along the anterior margin. Beak just meets the plane of commissure, being short and blunt; lateral margins of valves are rather sharp. Sinus short and shallow, confined

to the anterior third of the valve, merging gradually with the lateral slopes. Interarea ill-defined; width of delthyrium at hinge line is equal to half the length of the hinge line; pedicle interior with prominent dental plates.

Brachial valve more strongly convex than the pedicle, conspicuously bloated in the umbonal region, whence the surface curves abruptly to posterior lateral margins. Moderately and regularly arched transversely, slightly flexed mesially by a short shallow, broadly convex fold confined to the anterior part. Shell material impunctate. The spire consists of six to nine loops with apices directed dorso-laterally. Two processes unite to form a simple jugum which is located mid-length of shell and directed slightly posteriorly. Dimensions of average specimen are: length 12.5 mm., width 12 mm., thickness 8 mm.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Undoubted specimens known only from the B₁ limestone; widespread and common throughout that member. It is possible that small forms occur in the dwarfed complex at the base of the C₃ horizon on Hood Island. Collections from localities R-1, R-2, V-3, V-4 and I-4.

Composita windsorensis Bell

Plate XII, figs. 9-11

Composita windsorensis Bell, 1929, pp. 133-134, pl. 21, figs. 7-18a.

Discussion: This form is identical with Bell's types in every detail, except that the average individual is slightly smaller than the type area specimens. There are gradations between this species and C. dawsoni. Externally C. windsorensis has a more pronounced pentagonal outline, and C. dawsoni lacks a truncation effect on the anterior margin. Bell has pointed out that "the ventral beak is more delicate and less elevated in C. windsorensis".

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The species is common in the B₁ horizon at localities R-1 and I-4.

Composita obligata Bell

Plate XII, figs. 12-14;
Plate XIII, figs. 1-3.

Composita obligata Bell, 1929, pp. 135-136, pl. 20, fig. 26, pl. 21, figs. 1-2a.

Discussion: Two specimens are referable to this species. They conform closely to the holotype.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The specimens in the collection came from the B₁ horizon at locality R-1.

Superfamily PUNCTOSPIRACEA

Genus Spiriferina d'Orbigny 1847Spiriferina verneuili Bell

Plate XIII, figs. 4-9

Spirifer cristatus de Verneuil (non Schlotheim), Lyell,
1845, p. 221.

Spirifer minimus de Verneuil (non Sowerby), Lyell, 1845,
p. 221.

Spirifer octoplicatus de Verneuil (non Sowerby), Lyell,
1845, p. 221.

Spirifera cristata Davidson (non Schlotheim), 1863, pp.
170-171, pl. 9, fig. 6; Dawson, 1868, pp. 291-292, fig. 90.

Spirifera acuticostata Davidson (non de Koninck) 1863,
p. 171, pl. 9, figs. 7-8; Dawson, 1868, pp. 292-293, fig. 91.

Spiriferina verneuili Bell, 1929, pp. 139-141, pl. 22, figs.
6-9a.

Description: Shell small, gibbous, sub-triangular in outline. Lateral profile biconvex, pedicle valve with the greater convexity. Width exceeds length, and is greatest at the hinge line. Pedicle valve with greatest convexity near the umbonal region; beak prominent, high, acutely pointed, narrow, abruptly incurved but not meeting plane of commissure. Interarea triangular in shape, its height about 1.5 mm. for the average size individual. In lateral view interarea is at first inclined at about 90° to the plane of commissure. It curves smoothly toward the beak, the rate of curvature increasing rapidly into the overhang of the hooked beak. Triangular delthyrium conspicuous; in most specimens it does not show a covering plate, but a few individuals possess a deltidium which does not appear to be open at the apical end. Brachial interarea is inconspicuous, being concealed by overhang of brachial beak. There is a broad shallow pedicle sinus and a corresponding brachial fold. The coarse strongly marked radial sculpture involves the full thickness of the valves, so that the anterior commissure is conspicuously corrugated. Costae are somewhat sharp-crested and evenly spaced, 12 occurring on a mature shell. An average specimen measures 7 mm. long, 8 mm. wide and 5 mm. thick.

The internal structure shows the features characteristic of the genus. Spirals are supported by a connecting jugum. In a normal adult shell 10 mm. long each cone of the spiralia consists of 6 volutions. Pedicle valve with strong

diverging dental plates and prominent high median septum; notothyrial cavity in brachial valve bounded by narrow elongate crural plates. In old shells the umbonal cavity may become thickened by secondary shell material which extends up the sides of the dental lamellae and almost submerges them. In one such shell a plug-like callous almost fills the delthyrial cavity.

Distribution: Bell lists this species as having been found in both the Lower and Upper Windsor in the type region. Specimens in this collection are found only in the B₁ horizon of the Lower Windsor, where it is rare. Collections from localities R-1 and R-2.

Genus Punctospirifer North 1920

Punctospirifer sp.

Plate XIII, Figs. 10-13

Description: Shell small, biconvex; brachial valve weakly convex, pedicle valve strongly so. Shell wider than long with greatest width between the hinge line and the mid-length. Subpentagonal in outline with rounded cardinal extremities. Pedicle valve is 8 mm. long, 8.5 mm. wide, with convexity of 3.5 mm.; brachial valve is 6 mm. long, 8.5 mm. wide, with convexity of 2.5 mm. Pedicle valve most strongly arched in the umbonal region. Pedicle beak small, pointed, closely incurved to the plane of commissure. Sinus shallow,

broad, flat at the bottom, extending from beak to anterior margin. Lateral slopes curving gently from borders of sinus to lateral margins, and strongly arched from back to front. Interarea is divisible into two parts: a central, triangular delthyrial cavity filled with a plug-like callus, and an outer zone which is marked by horizontal striations, the latter representing extensions of the growth lines. Interarea is gently concave, more strongly curved beneath the beak. The lateral slopes bear strong rounded costae conspicuously corrugated by the growth lamellae. The costae are separated by rounded interspaces; they are coarsest next to the sinus and are progressively smaller towards the lateral margins, the sixth pair usually remaining low and obscure. The costate on either side of the sinus are considerably larger than the remainder. In addition to the costae, the surface is covered with heavy concentric growth lamellae, irregularly spaced, giving a shingled effect to the shell surface. The specimens show marked grouping of growth lines. At about mid-length of shell a group contains 8 lamellae in 1 mm. On the anterior part a group contains 5 lamellae in 1 mm. The anterior margin is distinctly corrugated and growth lines are crowded close together to fill a gap between the valves. The shell substance is coarsely punctate.

Brachial valve semitriangular in outline, strongly arched in umbonal region, regularly arched from side to side. Fold low, broad, flattened along the summit, slightly truncated

at the front. Umbo small, beak blunt and slightly projecting. Surface sculpture as in pedicle valve. No interiors have been observed.

Discussion: In contour and form this species is strongly suggestive of the genus Spiriferina. An excellent general review of the genera Punctospirifer and Spiriferina is given by King (1930:121, 124). Punctospirifer differs in having the heavy growth lamellae. Although it is the same size as Spiriferina verneuli Bell, the hinge line is shorter and the cardinal extremities are more rounded. This genus is represented by one example in the collections, and is inadequate for the erection of a new species.

Distribution: Mississippian Lower Windsor group of Nova Scotia. The single specimen came from the B₁ horizon at locality R-1.

Superfamily TEREBRATULACEA

Genus Beecheria Hall and Clarke 1893

Beecheria davidsoni (Hall and Clarke)

Plate XIII, figs. 14-16;
Plate XIV, figs. 1-2

Terebratula sufflata (non Schlotheim) Verneuil, (Lyell, 1855, p. 220).

Terebratula elongata (non Schlotheim) Dawson, 1855, p. 219, fig. 27e.

Terebratula sacculus (non Martin) Davidson, 1863, p. 169, pl. 9, figs. 1-3; Dawson, 1868, pp. 289-290, fig. 87.

Beecheria davidsoni Hall, 1894, p. 300, fig. 224, pl. 79, fig. 35; 1895, p. 372, pl. 14, figs. 8-9.

Dielasma sacculus (non Martin) Beede, 1911, p. 167, fig.

Dielasma davidsoni (Hall and Clarke), Bell, 1929, pp. 144-146 pl. 23, figs. 8-10, 15-18.

Description: Subpentagonal in outline. Lateral profile subequally biconvex, pedicle valve with the greater convexity. Greatest width slightly anterior to mid-length, narrowing gradually to the beak and contracting rather abruptly to the slightly rounded anterior margin. Pedicle beak slightly incurved, with large circular foramen generally encroaching on the umbo. Surface bearing concentric sculpture consisting of unevenly spaced growth lines, which become rather coarse near the anterior margin; no other sculpture. A specimen of average size measures 11 mm. long, 8 1/2 mm. wide, 7 mm. thick

Internally the dental sockets are deep and narrow; pedicle collar is well developed. In the brachial valve a spoon-shaped muscular plate unites the inner edges of the diverging crural lamellae; it may be distinctly separated from the floor of the valve, or may be fused to the floor. Crura are short and stout; crural processes project inwards and slightly downwards. The descending lamellae of the simple loop follow the curves of the brachial valve for approximately one-third the length of the shell. These descending branches diverge slightly and recurve abruptly, to form a rather sharp

V-shaped transverse connecting band. The lateral branch is fragile and usually destroyed in fossilization. The dental lamellae may be faintly developed or wholly absent.

Discussion: The genus Beecheria is characterized by reduced dental plates. In establishing the genus Hall (1894:300) stated: "the general character of the interior is that of Dielasma, except that the dental plates are wholly absent or represented only by faint ridges which never reach the bottom of the pedicle-valve". Cloud (1942:134) notes that "dental plates are absent in Harttella and obsolescent in Beecheria".

Bell referred this species to the genus Dielasma because one of the type specimens possesses dental plates, and because Bell found no specimens lacking dental plates (1929:144). The specimens in the present collection from the type area and Cape Breton show a slight amount of variation in the lack of dental plates, or in their rudimentary condition. It is possible that the specimens with strong dental plates collected by Bell should have been referred to Cranaena. Dr. G. A. Cooper has pointed out to the writer that the genus Dielasma requires restudy and "splitting", and it seems best to recognize the genus Beecheria for the Windsor specimens. At almost every locality yielding B. davidsoni this form appears as a member of a continuously varying series. Bell has split the "form species" B. davidsoni in four distinct species (1929:144-148), of which three are

represented in the present collection. B. davidsoni closely resembles Pseudodielasma perplexa Brill' (Newell, 1940, p. 318, pl. 10, figs. 5-12) but differs in the absence of a fold and sulcus.

Distribution: Mississippian, Windsor group of Nova Scotia. This is an abundant and widely distributed species which has been collected in great numbers throughout the B₁ horizon; it is less common in the C₃ and E₁ limestones. Collections from localities R-1, R-2, V-1, V-3, V-4, I-1, I-4 and I-5.

Beecheria latum (Bell)

Plate XIV, figs. 3-6

Dielasma latum Bell, 1929, p. 146-147, pl. 23, figs. 5-5b, 13-14; pl. 24, figs. 1-4c.

Discussion: This species is abundant in the collections in association with B. davidsoni. The association with B. davidsoni is a constant feature suggesting that the two represent a single varied species, but it is possible to select types to conform to both Hall and Clarke's, and Bell's species; hence the specimens have been separated. Both types are varied in proportion of length to width, and convexity. The size of the specimens assigned to B. latum varies considerably, the length ranging from 15 to 5 mm. and the width from 12 to 4 mm., with rare larger individuals. B. latum is slightly less gibbous and less elongate than the "form species".

Its greatest width is closer to mid-length than in B. davidsoni, and the beak is less massive.

Distribution: Mississippian, Windsor group of Nova Scotia. This is the most prolific form represented in the collections; abundant and widespread in the B₁ member. Collections were made at following locations: R-1, R-2, V-1, V-3, V-4 and I-4.

Beecheria milviformis (Bell)

Plate XIV, figs. 7-13

Dielasma milviformis Bell, 1929, p. 147, pl. 24, figs. 5-10.

Discussion: In comparison with B. latum, B. milviformis has its greatest width slightly posterior to mid-length of the shell, and it is less gibbous than B. latum. This species tends to be slightly flattened in the medial portion of the brachial valve. Internal features and sculpture similar to B. davidsoni.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. These forms are only moderately common, but have been collected throughout the B₁ limestone at localities R-1, R-2, V-1, V-3 and V-4.

Genus Cranaena Hall and Clark 1893

Cranaena tumida Bell

Plate XIV, figs. 14-17;
Plate XV, fig. 1

Cranaena tumida Bell, 1929, pp. 148-149, fig. 12, pl. 24, figs. 11-16; Cloud, 1942, p. 137.

Description: Shell small, swollen, suboval in outline; lateral profile biconvex, pedicle valve with greater convexity. Pedicle valve with heavy strongly hooked beak that bears a rounded foramen encroaching on the umbo. Greatest width of shell a little anterior to mid-length; surface smooth except for concentric growth lamellae which are strong in some specimens. No sinus present. Delthyrium largely occupied by the hidden incurved beak of the brachial valve. Specimen of average size measures 11.5 mm. long, 10 mm. wide and 7 mm. thick. Brachial valve a little less convex than the pedicle; commonly swollen in mid-region; sculpture as in pedicle valve.

Discussion: Superficially this species resembles certain gradational forms between Beecheria davidsoni and B. latum, found in the same beds. Internally it differs from the Beecheria forms in that its hinge plate is not adherent to the bottom of the brachial valve; the descending branches of its loop are more divergent than in Beecheria, and the fragile transverse connecting band makes a broad, gentle curvature. Dental plates are present in Cranaena, whereas they are lacking or obsolescent in Beecheria.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The species is common in the B₁ limestone; collected from localities R-1, V-1 and V-3.

Genus Romingerina Hall and Clarke 1893

Romingerina anna (Hartt), emend. Bell

Plate XV, figs. 2-4

Centronella anna Hartt (Dawson, 1868, p. 300, fig. 99).

Romingerina anna (Hartt), non Harttina anna Hall and Clarke (Bell, 1929, p. 129, pl. 20, figs. 12-15.)

Description: Extremely small, flattish delicate shell with biconvex profile; subcircular in outline; pedicle valve gently convex. Beak incurved with minute rounded apical foramen; umbone with high shoulders; surface smooth and punctate. Brachial valve with convexity about equal to that of pedicle valve, slightly arched in umbonal region. Bell describes the internal parts in his memoir. Average specimen measures 4 mm. in length, 4 mm. in width and 2 mm. in thickness.

Discussion: These shells were at first thought to represent young forms of other terebratellids found in the Windsor strata. However, the unique structure of the brachidium with its conspicuous median plate abruptly turned into a vertical plane from the lateral branches of a simple loop, makes it easily recognizable. The shell is easily crushed and it is therefore rather difficult to find specimens showing the external features. The shell represents the combination of smooth biconvex valves with a modified centro-nellid brachidium.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Common in the B₁ horizon; found at localities R-1, R-2, V-1, V-3, V-4 and I-4.

PHYLUM MOLLUSCA

Class PELECYPODA

Genus Sanguinolites McCoy 1844Sanguinolites parvus Bell

Plate XV, figs. 5-6

Sanguinolites parvus Bell, 1929, p. 152, pl. 25, figs. 5-10a.

Discussion: A number of examples in the collection represent young forms of this species. A characteristic form measures 8 mm. in length, 4.5 mm. in height and 3.5 mm. in thickness. Sculpture was not observed.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Common in the B₁ horizon; collections from localities R-1, R-2, V-1 and I-4.

Sanguinolites striatogranulatus Hind

Plate XV, fig. 7

Sanguinolites striatogranulatus Hind, 1900, pp. 393-394, pl. 42, figs. 16-22; Bell, 1929, p. 153, pl. 24, figs. 26-30, pl. 25, figs. 1-4.

Discussion: A single example in the collection agrees in all respects with Bell's fig. 4, plate 25.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Only one specimen was collected, from the B₁ limestone at locality R-1.

Genus Edmondia de Koninck 1841

Edmondia rudis McCoy

Plate XV, fig. 8

Cardiomorpha vindobonensis Hartt (Dawson, 1868, p. 304, fig. 109).

Edmondia rudis McCoy (Hind, 1900, pp. 302-304, pl. 27, figs. 15-15a, pl. 28, figs. 8-14; Bell, 1929, p. 155, pl. 25, figs. 14-18b).

Discussion: There are five well preserved individuals in the collections, from two localities. They agree well with the forms which the writer collected at Windsor, except that the Cape Breton forms are slightly smaller.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rather rare, specimens in this collection came from the B₁ limestone at localities R-1 and R-2.

Genus Grammatodon Meek and Hayden 1860

Subgenus Parallelodon Meek and Worthen 1866

Grammatodon (Parallelodon) hardingi Dawson

Plate XV, figs. 9-10

Macrodon hardingi Dawson, 1868, p. 302, fig. 102a, not figs. 102 b-c.

Macrodon curtus Dawson, 1868, p. 302.

Parallelodon hardingi (Dawson), Bell, 1929, p. 156, pl. 26, figs. 13-19.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The steinkerns occur in abundance throughout the B₁ limestone and are widespread in Cape Breton. Collections from the following localities: R-1 and R-2.

Grammatodon (Parallelodon) dawsoni Beede

Plate XV, fig. 11

Parallelodon dawsoni Beede, 1911, p. 168; Bell, 1929, pl. 26, figs. 9-12.

Parallelodon hardingi? Beede, 1911, p. 168.

Discussion: This species occurs in association with G. (P.) hardingi but is not so plentiful as the "form species". The individuals vary in size; unless the teeth and scars are seen, the relationships between G. (P.) dawsoni and G. (P.) hardingi are confusing. Nevertheless, the mean form of G. (P.) dawsoni does have a more highly inclined cardinal area and is less tumid than G. (P.) hardingi. Bell's figures show the surface sculpture whereas the test is not preserved on any of the Cape Breton specimens.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The species is common and is found only in the B₁ limestone. Collections from localities R-1 and R-2.

Genus Leptodesma Hall 1883

Leptodesma borealis Beede

Plate XV, fig. 12

Leptodesma borealis Beede, 1911, p. 169, fig.; Bell, 1929, p. 159, pl. 26, fig. 20.

Discussion: Only a few steinkerns of this species were collected and they agree quite well with Bell's description and illustration. Surface markings not observed.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rare; found only in the B₁ limestone at locality R-2.

Leptodesma acadica (Beede)

Plate XV, fig. 13

Liopteria acadica Beede, 1911, p. 170, fig.

Leptodesma acadica (Beede), Bell, 1929, p. 160, pl. 26, figs. 3-5.

Discussion: Four specimens in the present collection agree well with this species, except that the surface sculpture is not preserved. The figured example measures: length of hinge line 10 mm.; greatest oblique length 15.5 mm.; height at posterior end of hinge 10 mm.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rare; collected only from the B₁ limestone at localities R-2, V-1 and V-4.

Genus Schizodus King 1844

Schizodus cf. S. denysi Beede

Plate XV, figs. 14-16

Schizodus denysi Beede, 1911, p. 182, figs.

Description: Shell small, thin, inequilateral, outline subtrigonal. Anterior margin well-rounded. Posterior extremity narrowed, slightly truncate. Beak subterminal, low, slightly inturned but not clearly visible in lateral view of shell. Hinge line straight, about as long as the valve. Shell tapers gently from umbonal bulge to ventral margin. Shell material thick and chalky with heavy concentric sculpture in the best preserved examples. Recrystallization of the shell substance prevents study of teeth and hinge structure. Although articulated valves were not found, several right valves having same hinge length as left valves were alike as regards convexity and details of form. Measurements of a typical example are: length 12 mm., height 8 mm., convexity of a single valve 3 mm.

Discussion: When compared with Beede's figures of specimens from the Windsor beds of the Magdalen Islands, the Cape Breton forms display slight but constant differences in that the radial ridge is less pronounced and the beak is somewhat lower. When better-preserved specimens are found, this species may be no more than a variant of S. denysi Beede.

Distribution: Mississippian, Upper Windsor group of Cape Breton. There are many specimens of this species in the present collections. In Cape Breton it is extremely abundant in the lower half of the E₁ dolomite, and is widely distributed in the area investigated. At the type locality

no specimens have been referred to this species. Specimens in this collection from the following localities: I-1, I-2 and I-3.

Genus Aviculopecten McCoy, emend. Newell 1937

Aviculopecten lyelli Dawson

Plate XVI, figs. 1-3

Aviculopecten lyelli Dawson, 1868, p. 305, fig. 11.

Aviculopecten reticulatus Dawson, 1868, p. 306, fig. 112.

Aviculopecten lyelli Beede, 1911, pp. 171-172, figs.

Aviculopecten lyelli Dawson (Bell, 1929, pp. 164-165, pl. 27, figs. 9-15, pl. 28, figs. 1-3.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This is the most abundant pelecypod species in the Lower Windsor. It is widely distributed in the B1 limestone in the area investigated; most commonly found in the lower half of that zone. Collections from localities R-1, R-2, V-1, V-3, V-4 and I-4.

Aviculopecten lyelliformis Bell

Plate XVI, fig. 4.

Aviculopecten lyelliformis Bell, 1929, p. 65, pl. 29, figs. 1-2.

Discussion: Only two incomplete specimens of this species were collected. It is much larger than A. lyelli and there are seemingly no gradational forms.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The species is rare and confined to the B₁ limestone at localities R-1 and V-4.

Aviculopecten subquadratus Bell

Plate XVI, fig. 5;
Plate XVII, figs. 1-2.

Aviculopecten subquadratus Bell, 1929, p. 166, pl. 28, figs. 4-11.

Discussion: Bell states that the presence of a more subquadrate shape, oblique sulcus and coarser plication distinguish this species from A. lyelli. Only a few specimens were collected from two localities in Cape Breton. They are steinkerns and the radial sculpture is weak, but they agree with the forms figured by Bell.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Found only in the B₁ limestone, where it is rare. Collections from localities R-1 and V-1.

Genus Pseudamusium Klein 1853

Pseudamusium simplex (Dawson)

Plate XVII, figs. 3-5

Aviculopecten simplex Dawson, 1868, p. 306, figs. 103a-b.

Pseudamusium simplex (Dawson), Bell, 1929, p. 167, pl. 28, figs. 13-18.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Rare; collected only from the B₁ limestone at locality V-1.

Genus Lithophaga Bolten 1798

Lithophaga poolii (Dawson)

Plate XVII, figs. 6-7

Modiola poolii Dawson, 1868, p. 301

Modiola poolii Beede, 1911, p. 173, fig.

Lithophagus poolii (Dawson), Bell, 1929, p. 170, pl. 29, figs. 12-18.

Discussion: A number of valves of this distinctive shell in the collection indicate the common occurrence in the B₁ zone. Shell essentially like the typical form, except that it is slightly more gibbous, which does not seem to justify so much as a new variety. A typical form measures: length 16 mm, posterior height 6.5 mm.; gibbosity 5 mm.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. Common in the B₁ horizon; collections from localities R-2, V-1, V-3 and V-4.

Class GASTROPODA

Genus Stegocoelia Donald 1889Stegocoelia abrupta (Bell)

Plate XVII, fig. 8;

Plate XVIII, fig. 1

Murchisonia (Stegocoelia) abrupta Bell, 1929, p. 173, pl. 30, figs. 16-17.

Distribution: Mississippian, Upper Windsor group of Cape Breton. This species is confined to the C zone; at Hood Island it is abundant at the base of the C₃ limestone. Bell cites the species in the Lower Windsor at the type locality. Specimens in the present collection came from localities I-1 and I-5.

Stegocoelia compactoidea (Bell)

Plate XVIII, fig. 2

Murchisonia (Stegocoelia) compactoidea Bell, 1929, p. 174, pl. 30, figs. 13-15a.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This species was collected from the B₁ zone at two localities where it is scarce. The author cannot state with assurance that young forms of this species do not occur at the base of the C₃ limestone on Hood Island. Specimens in this collection from localities R-2, V-3 and I-4.

Genus Flemingia de Koninck 1881

Subgenus Anematina Knight 1933

Flemingia (Anematina) dispersa (Dawson)

Plate XVIII, fig. 3

Pleurotomaria dispersa Dawson, 1868, p. 310

Flemingia dispersa (Dawson), Bell, p. 177, pl. 31, figs. 9-10.

Discussion: The specimen figured is small for the species and poorly preserved, but it is a typical form. Its outline is characteristic and easily distinguished from any other.

Distribution: Mississippian, Upper Windsor group of Nova Scotia. Rare; collections from the base of the C₃ limestone at Hood Island.

Genus Naticopsis McCoy 1844

Naticopsis howi Dawson

Plate XVIII, figs. 4-5

Naticopsis howi Hartt, 1867, p. 212; Dawson, 1868, p. 309, fig. 119.

Naticopsis dispassa Dawson, 1868, p. 309, fig. 120.

Naticopsis howi Dawson, (Bell, 1929, p. 178, pl. 31, figs. 12-15.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. This is the most abundant gastropod species in the collections. It is common and widespread throughout

the B₁ limestone; also found in small numbers at the base of the C₃ limestone on Hood Island. It has been collected from the following localities: R-1, R-2, V-1, V-3, I-1 and I-4.

Class CEPHALOPODA

Subclass NAUTILOIDEA

Genus Diodoceras Hyatt 1900

Diodoceras avonensis (Dawson)

Plate XVIII, figs. 6-8;
Plate XIX, figs. 1-2

Nautilus avonensis Dawson, 1868, p. 311, figs. 124 a-b.

Endolobus avonensis Hyatt, 1883, p. 288; 1894, pp. 536-537, pl. 8, figs. 36-39.

Diodoceras avonensis (Dawson), Bell, 1929, pp. 183-184, pl. 33, figs. 4-7.

Description: Conch is planospirally coiled, expansion toward the aperture being at a regular rate. The successive whorls are in contact but make no impress on each other; there is no encroachment of one whorl on preceding whorls. The outer surface of the last whorl is arched more sharply than the transverse section of the preceding whorl on which it rests. In apertural view the shell has a sub-oval outline, with pronounced flattened transverse curvature, the lateral slopes sharply rounded. Width of aperture about 40% greater than its height. Margin of the aperture was not seen.

In mature specimens the concavity of the septa is 6 mm. The septa are smoothly curved and bowl-like. They join the cell wall along simple, slightly sinuous sutures, directly transverse ventrally and laterally. The septal neck is straight and extends from one septum to the next, forming an unbroken, sub-central siphuncular tube, about 1.5 mm. in diameter. Largest specimen in the collection consists of three volutions and may be essentially complete. It is about 65 mm. in diameter, and its maximum width is 30 mm. The last half of the outer whorl represents living chamber, which seems to be more globular than the inner whorls; umbilicus wide open, revealing all the inner whorls. Starting with the septum at the base of the large living chamber the first four camerae occupy a length of 18 mm., measured in the plane of the siphuncle.

Discussion: A significant feature of some conchs in the collection is the preservation of a layer which seems to represent the nacreous shell exterior. The shells are smooth, and at first were thought to represent a species of Bellerophon. The material was examined by Dr. J. B. Knight. Under the lens he demonstrated the presence of a faint hyponomic sinus, and almost imperceptible traces of growth lines on the inner whorls. Flower and Kümmel (1950:615) placed the genus Diodoceras in the Order Centroceratida, Family Triboloceratidae.

Distribution: Mississippian, Windsor group of Nova Scotia. At the type area Bell cites "an abundance of D. avonensis in the upper beds of the Miller and Maxner limestones", and uses this species as an index for the B zone. The present collections contain a large number of specimens of this species. It is common in the B₁ member, particularly in the lower third. Rare individuals are also found in the D₁ limestone on Hood Island, about 9 feet from the base of that member. Collections from the following localities: I-1 and R-1.

Genus Stroboceras Hyatt 1884

Stroboceras hartti (Dawson) ?

Plate XIX, fig. 3

Gyroceras hartti Dawson, 1868, p. 311, fig. 125.

Discites hartti Dawson, 1883, p. 10.

Stroboceras hartti Hyatt, 1883, p. 29.

Stroboceras hartti (Dawson), Bell, 1929, pp. 182-183, pl. 3, figs. 3-3b; pl. 34, figs. 1-2.

Stroboceras hartti Dawson (Shimer and Shrock, 1944, p. 545).

Description: The single specimen in the collection is a fragmentary external mold, and appears to represent one-half volution of the outer whorl. The figured portion of it has an overall length of about 13 mm., and tapers from 3.5 mm.

to 5.5 mm. in diameter in adapertural direction. The whorl in cross section agrees with Bell's figured specimen (1929, pl. 33, fig. 3b). The unique subquadrate section is somewhat flattened ventrally and laterally, and subrounded dorsally. The test has gibbous umbilical shoulders making the dorsum wider than the venter. There are four pairs of prominent longitudinal ridges at the four corners of a section of the whorl. At the adoral end of the test the ridges are 1.5 mm. apart on the dorsolateral shoulders, and 1.0 mm. apart on the ventrolateral shoulders. Siphuncle and sutures not observed.

Discussion: Until more complete specimens are available it is not possible to refer it definitely.

Distribution: Mississippian, Lower Windsor group of Nova Scotia. The single specimen in the collection came from the B₁ limestone at locality R-1.

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Figure 8. North shore of Hood Island, looking west toward Point Vertical, showing prominent exposures of limestones in the C and D zones. The camera is set up on the uppermost limestone in the B zone. Photo by courtesy of Professor Fairbairn.

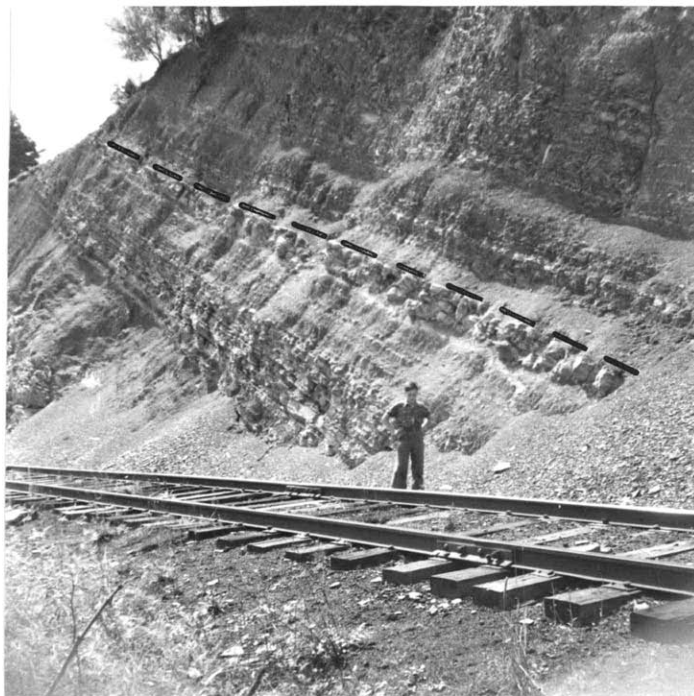


Figure 9. A significant contact in the lower Canso beds, 285 feet above the top of the Windsor. This exposure is in a railroad cut three quarters of a mile north of the Southwest Mabou Post Office. A thin botryoidal stromatolite marks the contact.



Figure 10. Typical lithology of the gray cross-bedded sandstones immediately below the Horton - Windsor contact.



Figure 11. Weathered surface of the dolomite at the base of the E zone, loaded with Schizodus cf. S. denysi; no other types of shells present.



Figure 12. Conoidal algal masses in the vertical beds of the C₃ limestone on Hood Island.

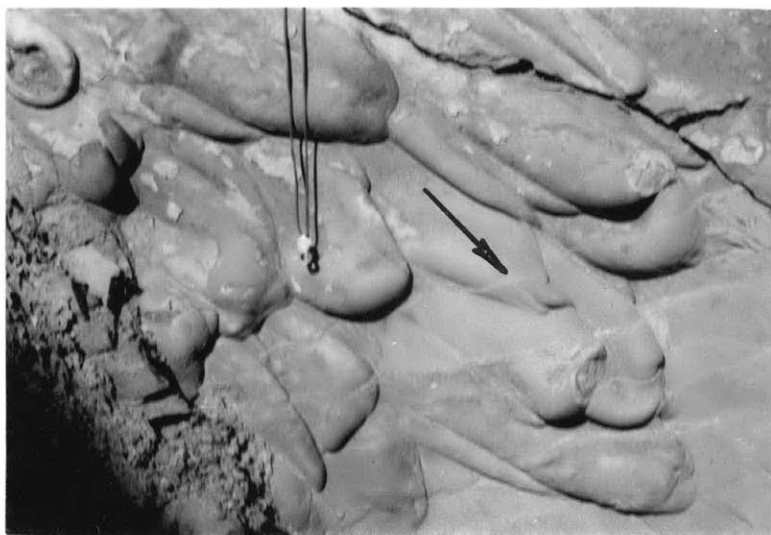


Figure 13. Flowcasts on base of Horton sandstone bed, near the Horton - Windsor contact, in the Southwest Mabou River. Hand lens gives scale. These are casts on the bottom of sandstones; the underlying mudstones have been removed. Arrow indicates direction of flow of water-filled sand.

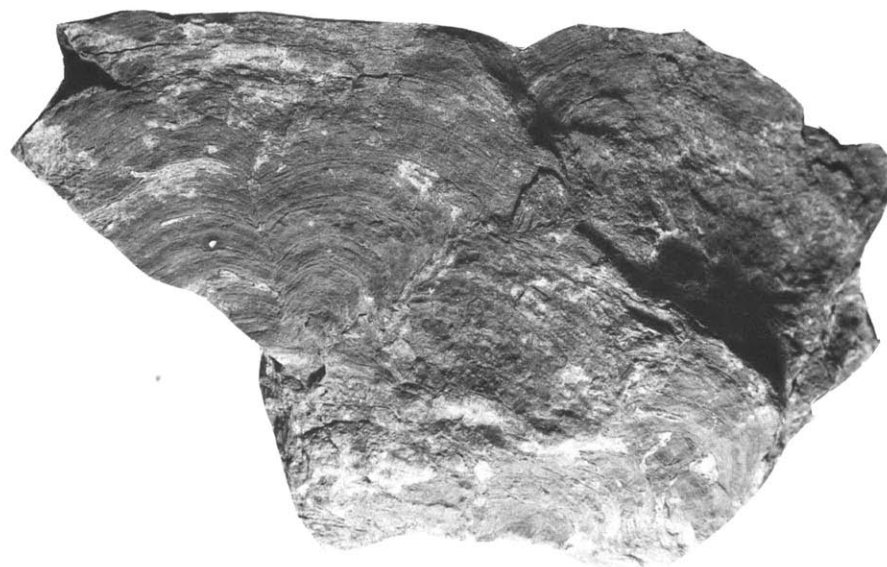


Figure 14. Typical algal structure ($\times \frac{1}{2}$) in the thin limestones at the top of the E zone of the Windsor, and at the base of the Canso.

PLATE I

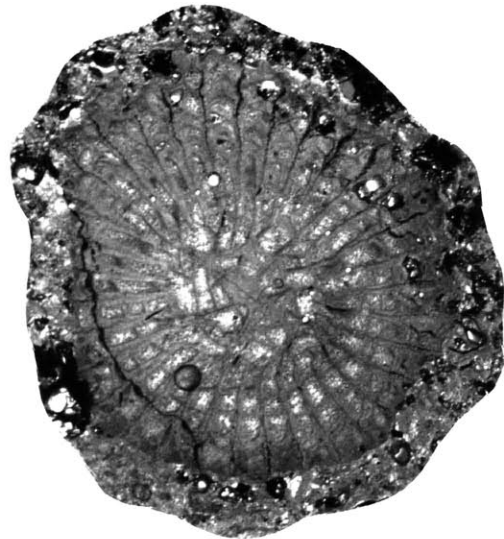
- Fig. 1 Nodosinella priscilla (Dawson)
1. Side view (x 10). Fl-H⁴. Locality I-1.
- Fig. 2-4. Dibunophyllum lambii Bell.
2-4. Series of transverse peel sections (x 4.5).
Co⁴-L2. Locality I-5.



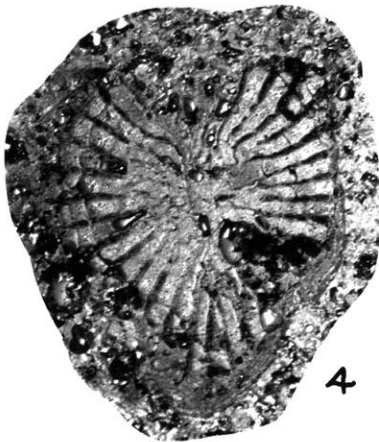
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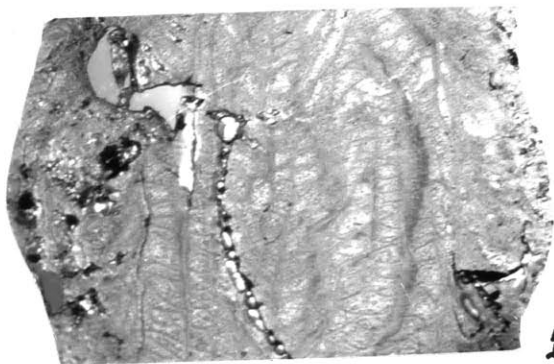
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PLATE II

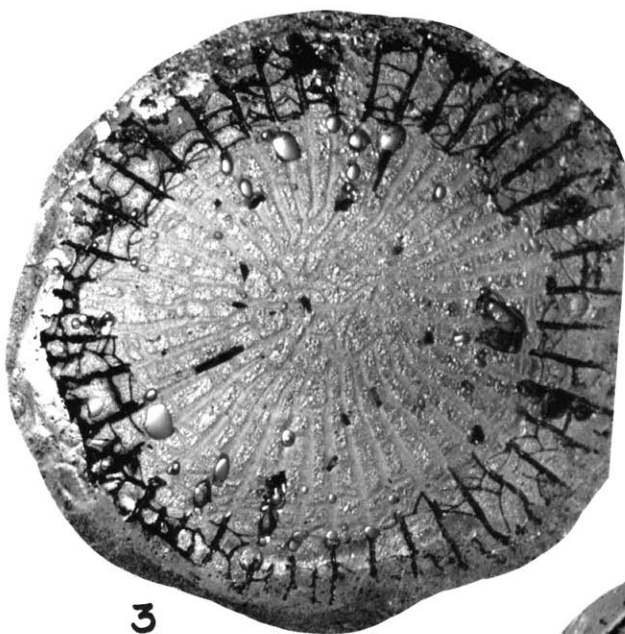
- Figs. 1-4. Dibunophyllum lambii Bell.
1. Longitudinal peel section (x 4).
Co4-L2. Locality I-5.
 2. Lateral view (x 1.3). Co4-G.
Locality I-6.
 - 3,4. Two transverse peel sections (x 4).
Co4-G. Locality I-6.



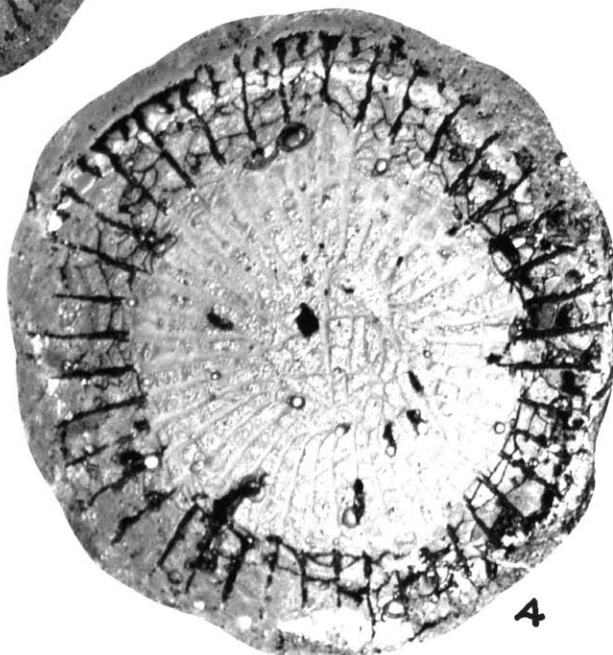
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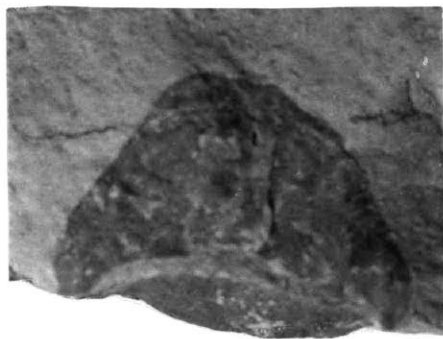


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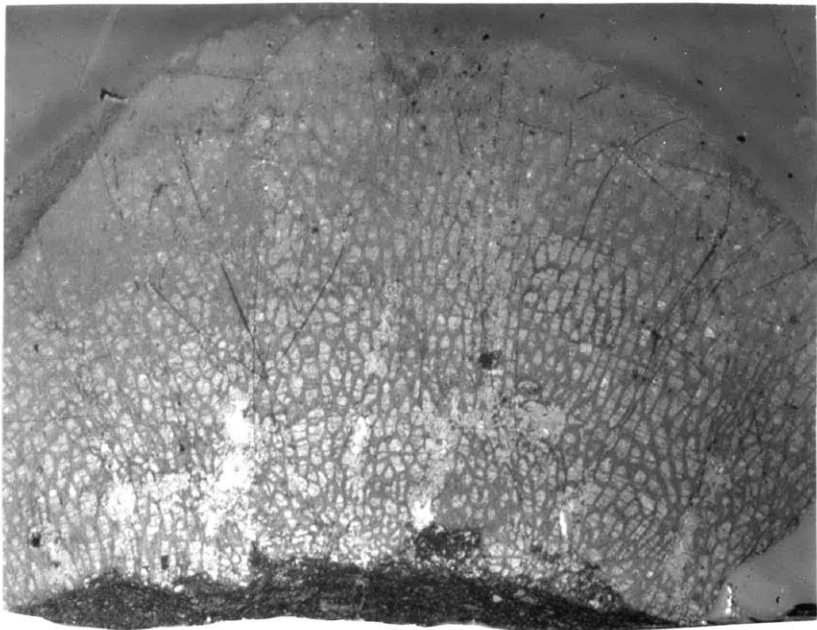
PLATE III

Figs. 1-3. Unidentified tabulate coral.

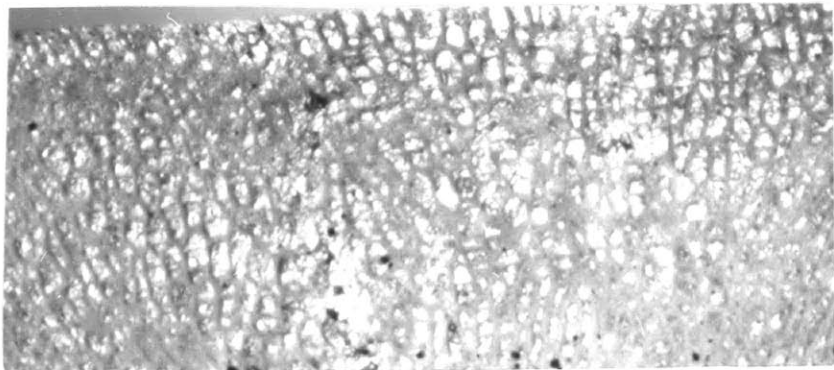
1. View of the vertical surface of a corallum broken in half, slightly larger than natural size. Co 9-H. Locality I-1.
2. Thin section cut longitudinally, very close to the center of the corallum (x 4). This section made from the specimen shown in fig. 1.
3. Cross section (peel) cut from the corallum shown in fig. 1 (x 8).



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PLATE IV

Fig. 1. Gonularia planicostata Dawson.

1. Surface of one face (x 2) showing the apertural end constricted by an incurved lobe. Co 6-J. Locality R-1.

Fig. 2. Serpula annulata (Dawson).

2. Side view (x 2). V 1-J. Locality R-1.

Figs. 3-4. Fenestrellina lyelli (Dawson).

3. Reverse surface of a zoarium (x 2). Bz 1-J1. Locality R-1.
4. Reverse surface of a zoarium (x 4). Bz 1-J2. Locality R-1.

Fig. 5. Septopora primitiva Bell.

5. Zooecial surface (x 4). Bz 3-L1. Locality I-4.

Fig. 6. Streblotrypa biformata Bell.

6. Zoaria encrusting Composita obligata (x 2.5). Bz 7-J1. Locality R-1.



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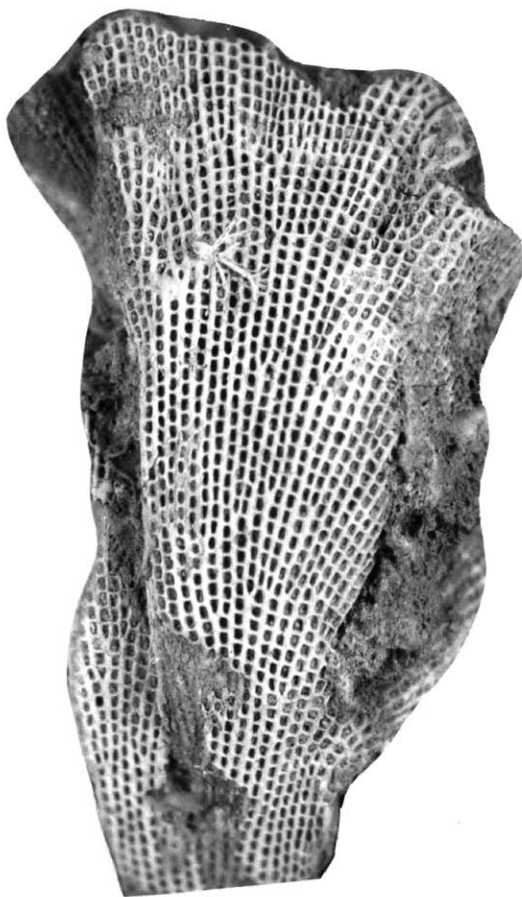
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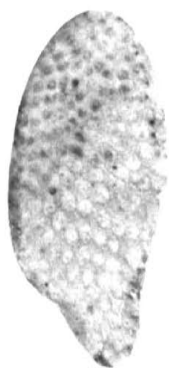
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PLATE V

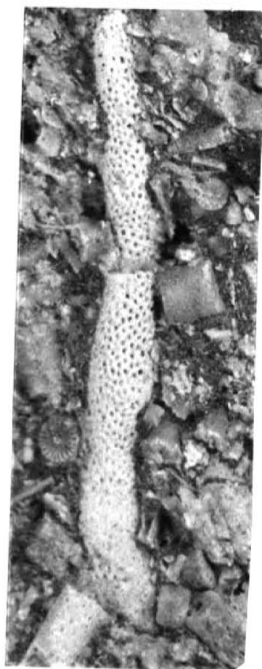
- Fig. 1. Streblotrypa biformata Bell.
An encrusting zoarium (x 9). Bz 7-J2.
Locality R-1.
- Figs. 2-4. Batostomella exilis (Dawson)
2. Exterior view (x 4.5). Bz 4-I. Locality R-2.
3. Exterior view (x 4.5). Bz 4-C. Locality V-3.
4. Longitudinal peel section (x 10). Bz 4-C1.
Locality V-3.
- Fig. 5. Weathered face of B₁ limestone with several
free zoaria of Batostomella exilis, and
specimens of Streblotrypa biformata
encrusting brachiopods (x 2.5). Locality R-1.



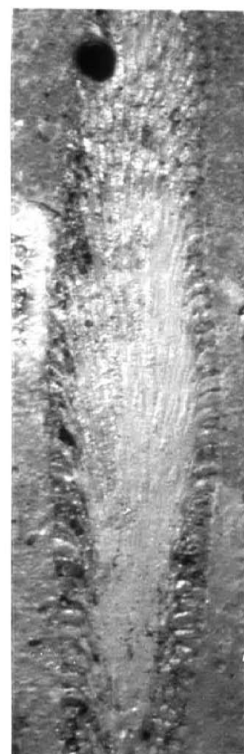
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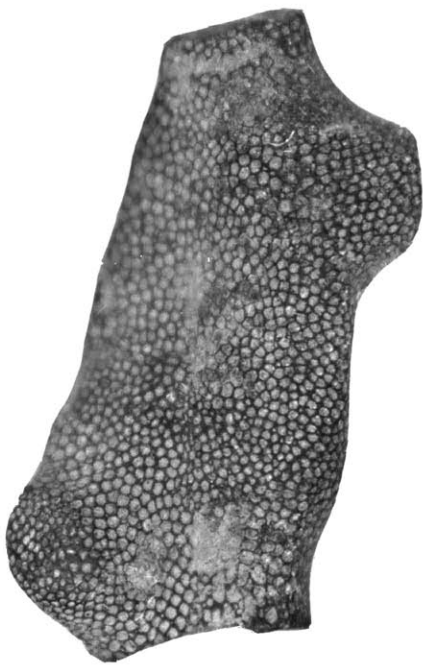
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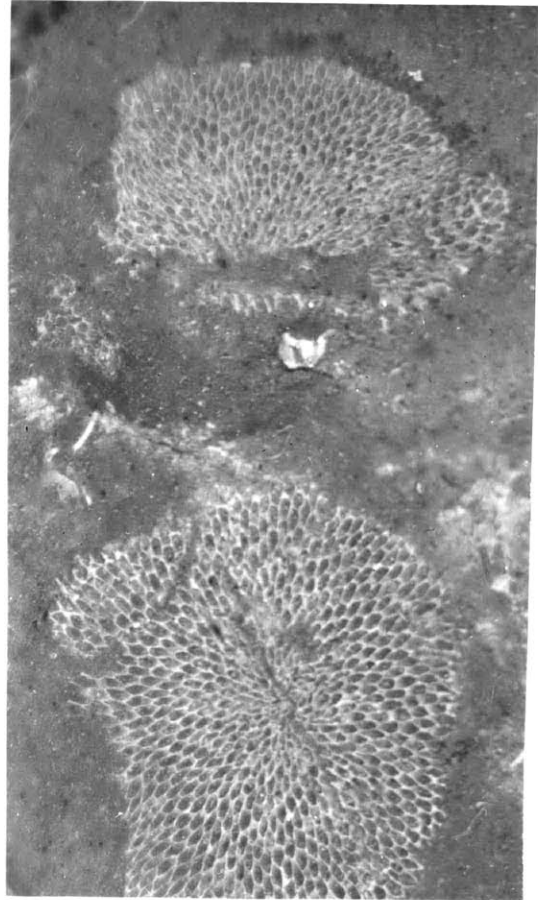
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PLATE VI

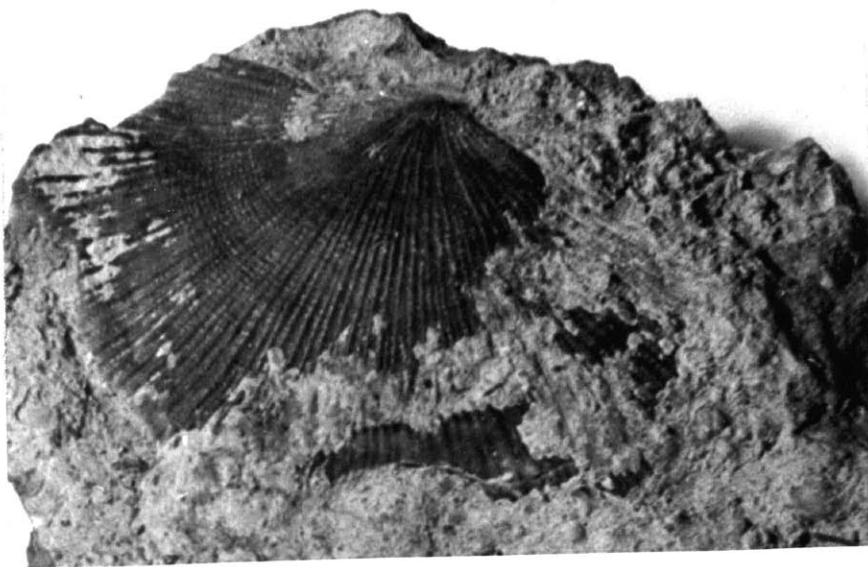
- Fig. 1. Tabulipora acadica Bell.
1. Exterior surface of zoarium (x 4).
 Bz 8-D. Locality V-4.
- Fig. 2. Unidentified Bryozoan.
2. Weathered surface showing two fragmental
 zoaria partially imbedded in matrix (x 8).
 Bz 9-MR. Locality V-2.
- Fig. 3. Schellwienella sp.
3. Imperfect pedicle valve (x 2.5).
 Bh 5-C1. Locality V-3.



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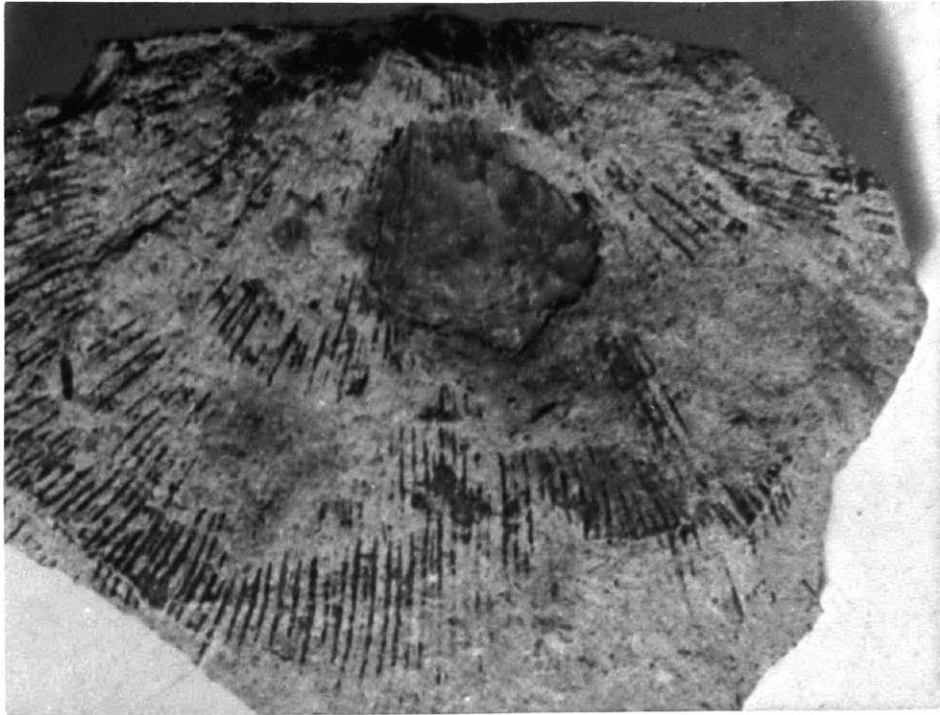
PLATE VII

Figs. 1-2. Schellwienella sp.

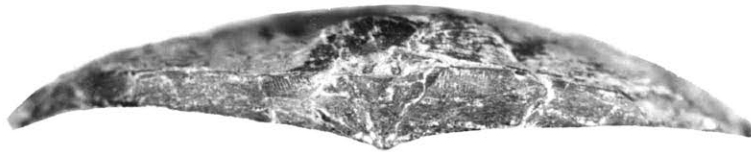
1. Pedicle exterior (x 2.5). Bh 5-G2.
Locality V-3.
2. Posterior view of articulated valves,
pedicle valve uppermost (x 2.5).
Note convex deltidium. Same specimen
as shown in figure 1.

Figs. 3-4. Productus productus var. tenuicostiformis
(Beede).

3. Lateral view (x 2.5). Bh 20-D1.
Locality V-4.
4. Pedicle view (x 2). Bh 20-I. Locality
R-2.



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PLATE VIII

Figs. 1-3. Productus productus var. tenuicostiformis
(Beede).

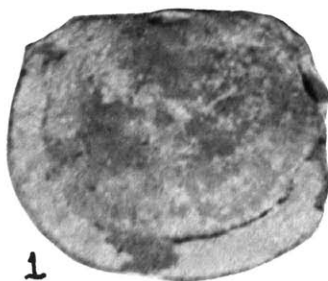
1. Interior of brachial valve showing well-developed diaphragm 2mm. wide at anterior margin (x 3.5). Bh 20-MR. Locality V-1.
2. Brachial view (x 4). Bh 20-J. Locality R-1.
3. Posterior view (x 3.5). Bh 20-D2. Locality V-4.

Figs. 4-8. Linoproductus lyelli Verneuil.

- 4,5. Lateral and pedicle views (x 2) of a complete specimen. Bh 10-D1. Locality V-4.
6. Full view of an imprint of a brachial valve (x 3). Bh 10-C. Locality V-3.
7. Posterior view of inner surface of brachial valve (x 3). Bh 10-D 2. Locality V-4.
8. A crushed brachial valve (x 2.5). Bh 10-I. Locality R-2.

Figs. 9-12. Linoproductus lyelli var. a. (Bell).

9. Full view of an imprint of a brachial valve (x 3). Bh 11-J1. Locality R-1.
10. Posterior view of a complete specimen (x 3). Bh 11-J2. Locality R-1.
11. Exterior of pedicle valve (x 3). Bh 11-I. Locality R-2.
12. Lateral view of specimen shown in fig. 10 (x 3).



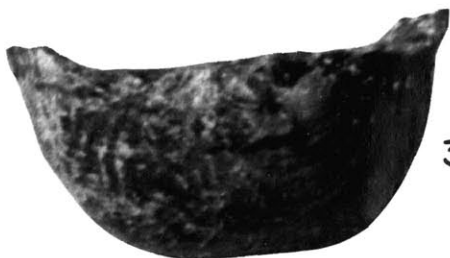
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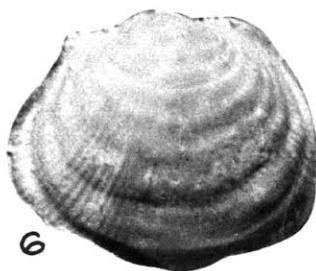
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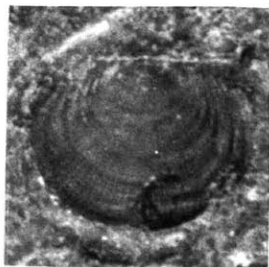
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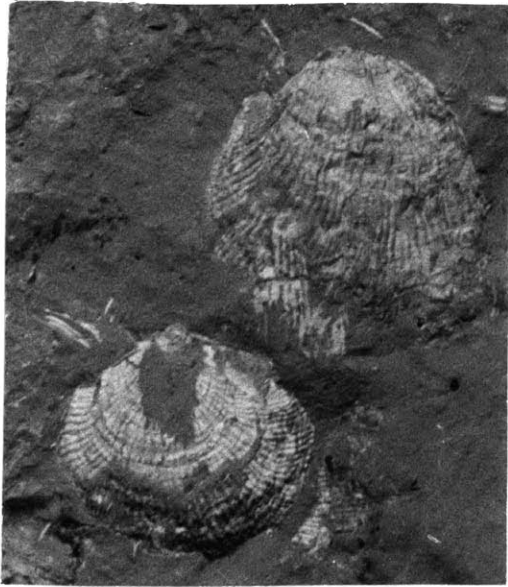
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PLATE IX

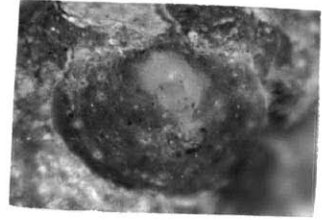
- Fig. 1. Linoproductus semicubicalus (Bell).
1. Crushed pedicle valve at top of photo,
 and crushed brachial valve below (x 3).
 Note stout, long spines at posterior
 margins. Bh 13-MR. Locality V-2.
- Fig. 2. Avonia sp.
2. External view of pedicle valve (x 4.5)
 Bh 17-J. Locality R-1.
- Figs. 3-11. Pugnax dawsonianus (Davidson).
- 3,4. Brachial and anterior views (x 3) of a
 specimen with costae nearly obsolete.
 Bh 25-J1. Locality R-1.
- 5,6,7. Pedicle, anterior, and brachial views
 (x 3) of a large specimen with 3 costae
 on fold. Bh 25-J2. Locality R-1.
- 8,9,10. Pedicle, anterior, and lateral views
 (x 4) of a specimen with 2 costae on
 fold. Bh 25-MR. Locality V-1.
11. Lateral view (x 4) of another specimen.
 Bh 25-D. Locality V-4.
- Figs. 12-15. Pugnax magdalena (Beede).
- 12-15. Brachial, posterior, anterior, and
 lateral views (x 3.5). Bh 26-J.
 Locality R-1.



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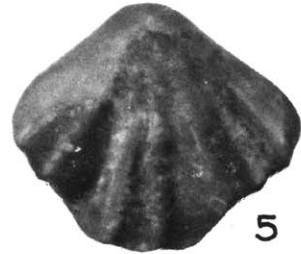
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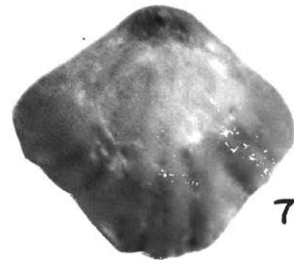
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PLATE X

Figs. 1-4. Shumardella ? sp.

1. Pedicle view (x 2). Bh 53-J1.
Locality R-1.
2. Anterior view (x 2). Bh 53-J2.
Locality R-1.
3. Lateral view (x 2). Bh 53-J3.
Locality R-1.
4. Pedicle view (x 2). Bh 53-J4.
Locality R-1.

Figs. 5-6. Spirifer ? sp.

- 5,6. Full view, and posterior view (x 2)
of a pedicle valve. Bh 37-MR.
Locality V-2.

Figs. 7-9. Ambocoelia? acadica Bell.

7. Pedicle view (x 2). Bh 41-C1.
Locality V-3.
- 8,9. Posterior and lateral views (x 2) of
the same specimen. Bh 41-C2.
Locality V-3.

Fig. 10. Martinia galataea Bell.

10. Posterior view of pedicle valve
(x 4). Bh 42-H1. Locality I-1.



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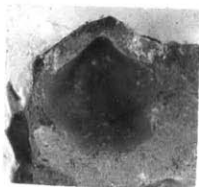
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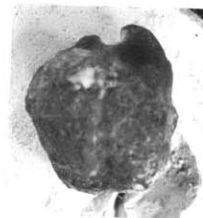
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PLATE XI

- Figs. 1-5. Martinia galataea Bell.
1. Pedicle view (x 4.5) Bh 42-H2.
 Locality I-1.
 - 2,3. Pedicle and anterior views (x 3)
 of a complete specimen with
 pronounced growth lamellae.
 Bh 42-MR. Locality V-2.
 4. An imperfect brachial valve (x 3).
 Bh 42-H3. Locality I-1.
 5. Interior of pedicle valve (x 3)
 showing strong radiating ribs.
 Bh 42-H4. Locality I-1.



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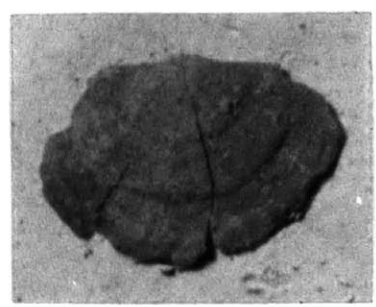
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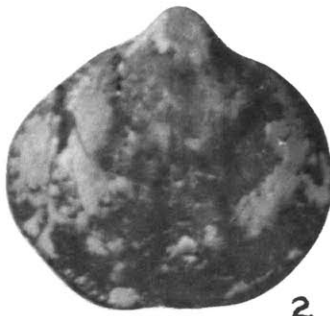
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PLATE XII

- Fig. 1. Martinia thetis Bell.
1. Pedicle valve (x 2). Bh 43-H. Locality I-1.
- Figs. 2-8 Composita dawsoni (Hall and Clarke).
2. Pedicle view (x 3). Bh 32-D. Locality V-4.
3. Brachial view (x 2.5) of same specimen.
- 4,5. Anterior and posterior views of a smaller specimen (x 3). Bh 32-J1. Locality R-1.
6. Interior of brachial valve (x 2). Bh 32-J2. Locality R-1.
7. Lateral view (x 3). Bh 32-I. Locality R-2.
8. Interior of brachial valve (x 3) showing jugum (spiralia has been broken off). Bh 32-J3. Locality R-1.
- Figs. 9-11. Composita windsorensis Bell.
- 9-11. Brachial, lateral, and anterior views (x 3). Bh 33-J. Locality R-1.
- Figs. 12-14. Composita obligata Bell.
- 12-14. Pedicle, brachial, and anterior views (x 3). Bh 35-J1. Locality R-1.



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PLATE XIII

Figs. 1-3. Composita obligata Bell.

- 1,2. Posterior and lateral views (x 3) of the specimen shown in Plate XII, figures 12-14.
- 3. Lateral view of a large, slightly deformed specimen (x 3). Bh 35-D. Locality V-4.

Figs. 4-9. Spiriferina verneuili Bell.

- 4. Pedicle view (x 2.5). Bh 39-J1. Locality R-1.
- 5. Brachial view (x 3). Bh 39-J2. Locality R-1.
- 6. Posterior view (x 3) showing open delthyrium. Bh 39-J3. Locality R-1.
- 7. Lateral view (x 3). Bh 39-J4. Locality R-1.
- 8. Interior of brachial valve (x 4). Bh 39-J5. Locality R-1.
- 9. Hinge line view (x 3) showing interior of articulated valves. Note diverging dental plates and strong median septum in pedicle valve. Bh 39-J6. Locality R-1.

Figs. 10-13. Punctospirifer sp.

- 10-12. Pedicle, posterior, and lateral views (x 2) of the same specimen. Bh 52-J. Locality R-1.
- 13. Anterior view (x 3) of same specimen. Note strong growth lamellae.

Figs. 14-16. Beecheria davidsoni (Hall and Clarke).

- 14-16. Pedicle, brachial, and lateral views (x 3) of the same individual. Bh 44-J1. Locality R-1.



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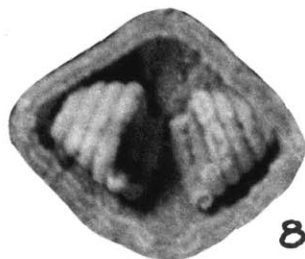
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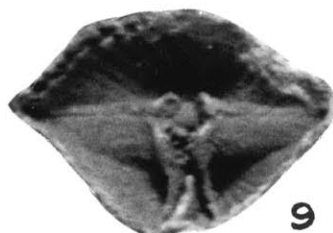
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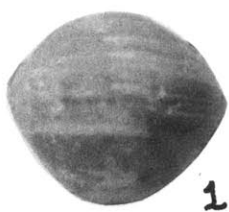
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PLATE XIV

- Figs. 1-2. Beecheria davidsoni (Hall and Clarke).
1. Anterior view (x 3.5). Bh 44-MR. Locality V-1.
 2. Interior of brachial valve (x 3). Bh 44-J2. Locality R-1.
- Figs. 3-6. Beecheria latum (Bell).
3. Pedicle view (x 3). Bh 45-MR1. Locality V-1.
 4. Brachial view (x 3) of a slightly larger specimen. Bh 45-C. Locality V-3.
 - 5,6. Lateral and anterior views (x 3) of another individual. Bh 45-MR2. Locality V-1.
- Figs. 7-13. Beecheria milviformis (Bell).
7. Pedicle view (x 3.5). Bh 46-C. Locality V-3.
 8. Brachial view (x 3) of another specimen. Bh 46-MR. Locality V-1.
 - 9-11. Lateral, anterior, and posterior views (x 3) of a third specimen. Bh 46-J1. Locality R-1.
 12. Brachial view (x 3) of a small individual. Bh 46-J2. Locality R-1.
 13. Brachial view (x 3) of another specimen. Bh 46-J3. Locality R-1.
- Figs. 14-17. Cranaena tumida Bell.
- 14-16. Pedicle, brachial, and lateral views (x 3) of the same specimen. Bh 48-J1. Locality R-1.
 17. Interior of brachial valve (x 3). Bh 48-J2. Locality R-1.



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PLATE XV

- Fig. 1. Cranaena tumida Bell.
1. Hingeline view showing interior of joined valves (x 3). Bh 48-J3. Locality R-1.
- Figs. 2-4. Romingerina anna (Hartt).
- 2,3. Brachial and posterior views (x 5) of the same specimen. Bh 31-J1. Locality R-1.
4. Interior of brachial valve (x 6). Bh 31-J2. Locality R-1.
- Figs. 5-6. Sanguinolites parvus Bell.
5. Right valve (x 2). Pl-I. Locality R-2.
6. Dorsal view, both valves (x 2). Same specimen as shown in figure 5.
- Fig. 7. Sanguinolites striatogranulatus Hind.
7. Left valve (x 1.5). P2-J. Locality R-1.
- Fig. 8. Edmondia rudis McCoy.
8. Left valve (x 2). P5-J. Locality R-1.
- Figs. 9-10. Grammatodon (Parallelodon) hardingi Dawson.
9. Anterior view (x 2). P7-1. Locality R-2.
10. Right valve (x 2). P7-J. Locality R-1.
- Fig. 11. Grammatodon (Parallelodon) dawsoni Beede.
11. Left valve (x 2). P8-I. Locality R-2.
- Fig. 12. Leptodesma borealis Beede.
12. Left valve (x 2). P9-1. Locality R-2.
- Fig. 13. Leptodesma acadica (Beede).
13. Left valve (x 2). Pl1-I. Locality R-2.
- Figs. 14-16 Schizodus cf. S. denysi Beede
14. Right valve (x 2). Pl5-H1. Locality I-1.
15. Right valve (x 2) of another specimen. Pl5-H2. Locality I-1.
16. Left valve (x 2). Pl5-H3. Locality I-1.



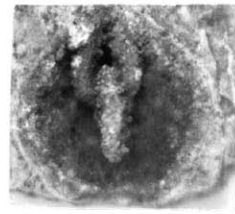
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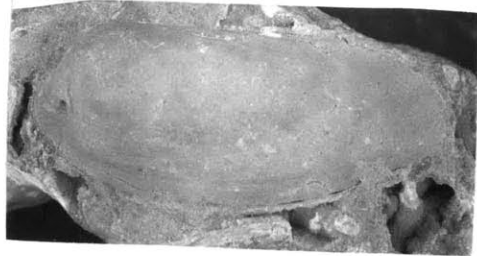
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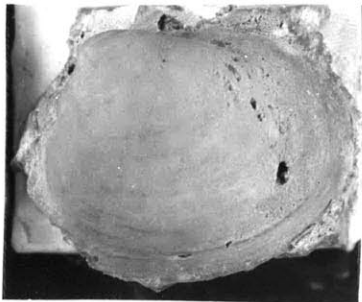
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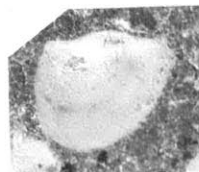
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14



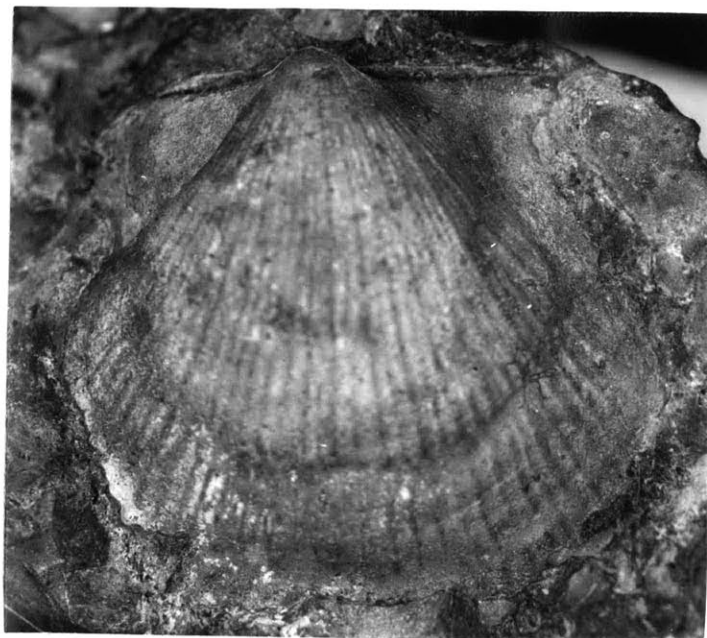
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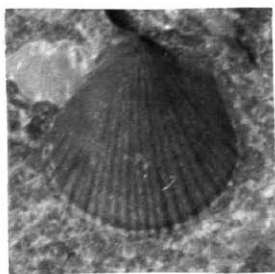
16

PLATE XVI

- Figs. 1-3. Aviculopecten lyelli Dawson.
1. Left valve (x 3.5) of a typical individual. P17-D1. Locality V-4.
 2. Left valve (x 2.5) of a small specimen. P17-D2. Locality V-4.
 3. Anterior view (x 2.5) of joined valves. P17-J. Locality R-1.
- Fig. 4. Aviculopecten lyelliiformis Bell.
4. Left valve (x 2). P18-D. Locality V-4.
- Fig. 5. Aviculopecten subquadratus Bell.
5. Left valve (x 3). P19-MR1. Locality V-1.



1



2



3



4



5

PLATE XVII

- Figs. 1-2. Aviculopecten subquadratus Bell.
- 1,2. Anterior and dorsal views (x 3) of the same specimen, with joined valves. P19-MR2. Locality V-1.
- Figs. 3-5. Pseudamusium simplex (Dawson).
- 3-5. Left valve, anterior, and dorsal views (x 3) of the same specimen, with joined valves. P21-MR. Locality V-1.
- Figs. 6-7. Lithophaga poolii (Dawson).
6. Right valve (x 2). P25-D. Locality V-4.
7. Dorsal view (x 2.5) of another specimen. P25-MR. Locality V-1.
- Fig. 8. Stegocoelia abrupta (Bell).
8. Weathered surface of C₃ limestone from Hood Island, loaded with Stegocoelia abrupta (x 10). G6-H.



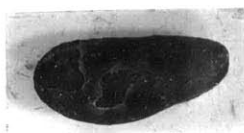
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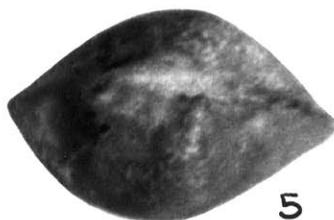
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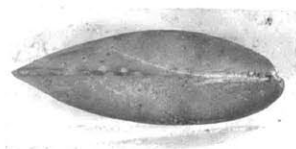
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4



8

PLATE XVIII

- Fig. 1. Stegocoelia abrupta (Bell).
 1. External mold (x 5). G6-L2.
 Locality I-5.
- Fig. 2. Stegocoelia compactoidea (Bell).
 2. External mold (x 5). G7-L1.
 Locality I-4.
- Fig. 3. Flemingia (Anematina) dispersa (Dawson).
 3. A normal individual (x 6). G14-H.
 Locality I-1.
- Fig. 4-5. Naticopsis howi Dawson.
 4,5. Side view (x 2) and top view (x 2.5)
 of the same specimen. G16-J.
 Locality R-1.
- Figs. 6-8. Diodoceras avonensis (Dawson).
 6,7. Lateral and ventral views (x 1.5) of
 a specimen. C6-J1. Locality R-1.
 8. View of a specimen with the shell
 material preserved (x 1.5) C6-J2.
 Locality R-1.

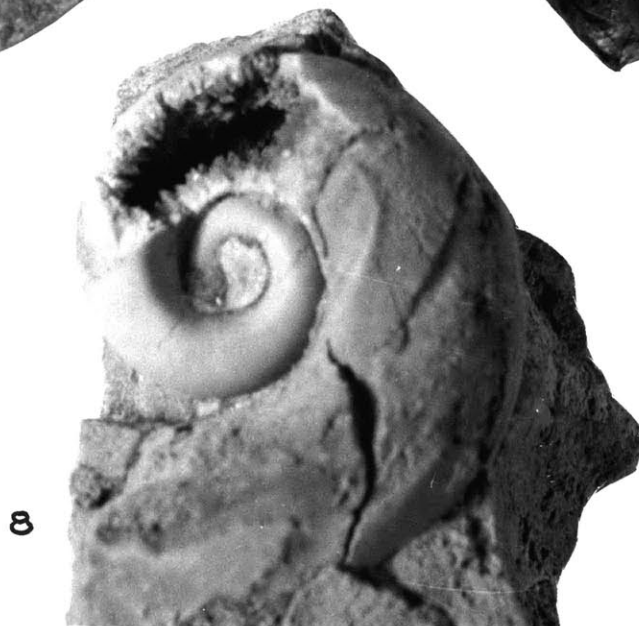


PLATE XIX

Figs. 1-2. Diodoceras avonensis (Dawson).

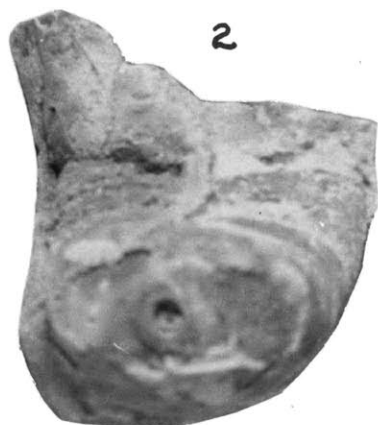
1. A fragmental specimen, slightly larger than natural size. C6-H. Locality I-1.
2. View of end showing siphuncle (x 2). C6-J3. Locality R-1.

Fig. 3. Stroboceras hartti (Dawson) ?

3. A fragmental specimen (x 2.5). C5-J. Locality R-1.



1



2

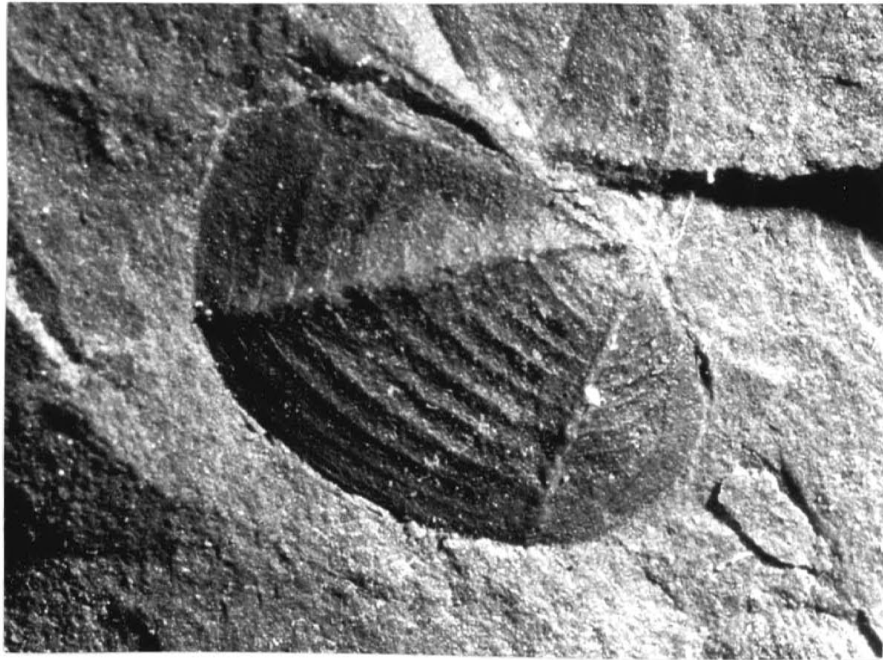


3

PLATE XX

(Forms representing the species illustrated on this page were collected from many horizons in the Canso beds, exposed along the Southwest Mabou River).

- Fig. 1. Leaia leidyi var. salteriana Jones
 (x 15). 01-MJ.
- Fig. 2. Modiolopsis sp. (x 2.5). P30-MJ.
- Figs. 3-4. Anthracomya angulata Dawson
 (x 7). P29-MJ.



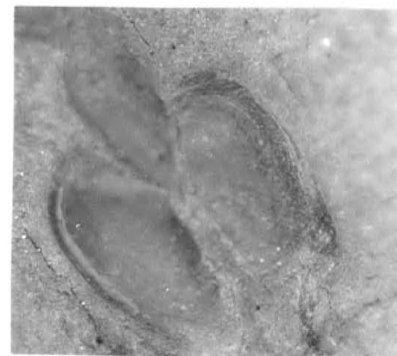
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4

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Massachusetts Institute of Technology 1949-50 and
1950-51. Member of Sigma Xi.

GEOLOGICAL MAP
OF
NOVA SCOTIA

SCALE: ONE INCH TO SIXTEEN MILES = 1:1013,760

16 0 16 32 48 MILES

LEGEND

MESOZOIC

TRIASSIC

16

Basalt and diabase;
16a, diabase (may be
pre-Triassic)

15

ANNAPOLIS FORMATION:
conglomerate, sandstone, shale

PALÆOZOIC

CARBONIFEROUS

14

RIVERSDALE, CUMBERLAND, and
PICOU GROUPS: sandstone, shale,
conglomerate, coal

13

MISSISSIPPIAN OR PENNSYLVANIAN
CANO GROUP: shale, sandstone,
conglomerate, limestone; volcanic rocks

12

MISSISSIPPIAN
WINDSOR GROUP: limestone, gypsum,
anhydrite; shale, sandstone; includes
MIDDLEBOROUGH, MACUMBER (?),
PEMBROKE, TENNYCAPE, MARAS
BROOK, and ARDNES FORMATIONS

11

HORTON GROUP: sandstone, shale,
conglomerate

10

LOWER DEVONIAN
Granite, gabbro, and allied rocks

9

Shale, limestone, conglomerate;
volcanic rocks;
9a, McADAM LAKE FORMATION;
9b, KNOYDART FORMATION

8

SILURIAN
Conglomerate, sandstone, shale,
limestone, argillite;
8a, ARISAIG SERIES;
8b, KENTVILLE FORMATION

7

ORDOVICIAN
MIDDLE ORDOVICIAN
6, MALIGNANT COVE FORMATION:
conglomerate, grit
7, STEWART BROOK FORMATION:
conglomerate, grit, argillite

5

LOWER ORDOVICIAN
Granite, monzonite, rhyolite

4

BROWNS MOUNTAIN GROUP:
sandstone, slate, argillite, quartzite;
volcanic rocks; schist

3

CAMBRIAN (Mainly)
Conglomerate, sandstone, shale,
limestone; volcanic rocks

PALÆOZOIC (Mainly)

CARBONIFEROUS OR EARLIER

E

Chiefly granitic rocks

D

Cobequid complex of
sedimentary and
volcanic rocks cut by
granitic intrusions (E)

PROTEROZOIC

2

Volcanic rocks; minor
sedimentary rocks

ARCHÆAN

1

GEORGE RIVER GROUP:
limestone, dolomite, quartzite;
argillite; volcanic rocks;
schist, gneiss

PRECAMBRIAN (Mainly)

PRE-CARBONIFEROUS

C

Mainly granitic rocks and
metamorphosed sediments

B

MEGUMA (Gold-bearing) SERIES:
comprises HALIFAX FORMATION
of slate and argillite, and
GOLDENVILLE FORMATION
of quartzite and slate

A

Granite, gabbro, and allied
rocks; younger than 1, in
part younger than 2

